No. 2. — *Some North American Fresh-Water Rhynchobdellidæ, and their Parasites.*[1] By W. E. Castle

CONTENTS.

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I. INTRODUCTION.

In the fall of 1897 a small leech, which is very abundant in the ponds about Cambridge, Massachusetts, was selected as an object for study in the class in Microscopical Anatomy in Harvard University. This selection brought under my observation a rather large number of leeches living or prepared in one of various ways, and gave occasion to the studies out of which this paper has grown. The kindness of friends has greatly aided me in obtaining material. In this connection my thanks are due to Mr. G. M. Allen, who sent me living leeches from the White Mountains in New Hampshire and also collected for me much valuable material in Massachusetts; to the Museum of Comparative Zoölogy for the privilege of studying its collection of leeches; to Professor James G. Needham, who sent me collections made in New York and Illinois, and also loaned me for study the collection of leeches belonging to Lake Forest University; to Dr. C. A. Kofoid, who obtained for me leeches from Havana, Illinois; to Mr. R. H. Johnson, for specimens collected in Lake Chautauqua, N.Y.; and last but not least, to Professor E. L. Mark and Dr. Otto Zur Strassen, who collected and preserved for me individuals of several European species.

Professor Whitman, who has given so much attention to the study of leeches, several years ago (**'91[a]**) pointed out the inadequacy of all descriptions then existing of our North American species of "Clepsine," showing that the descriptions in question were based on characters altogether too superficial and unreliable. Whitman himself presented a model in his description of "Clepsine plana;" but as this has not been followed by any similar account of our other species, I have thought it worth while to record in this paper some observations of my own, together with the views regarding the external morphology and relationships of our common species, to which studies, chiefly anatomical, have led me.

II. METHODS.

For the study of the general anatomy of a leech and particularly for the study of its external morphology, it is important to have both living animals and those which have been killed in a good state of extension. Of the former I have been fortunate enough to obtain an abundance; in preparing the latter I have found very serviceable the method recommended by Lee ('94, p. 17) of stupefying with carbonated water.[1] The animals are placed in a Stender dish and covered with water from a "soda siphon." As soon as they are thoroughly stupefied, they should be quickly transferred to the killing fluid, which is best used warm, not boiling hot, but heated to about 70°C. A stay of from two to five minutes in the carbonated water usually suffices to stupefy the smaller species enough for successful fixation, and indeed is better than more prolonged treatment. For if the animal still possesses a slight degree of irritability, it will usually straighten out in the warm killing fluid and die in a better state of extension than it was in before. The large species require a much longer treatment with the carbonated water. The best reagent to use in killing animals for whole preparations is, in my experience, Perenyi's fluid, which leaves the animal well extended and renders it clear and transparent. It has the property of removing pigment from the body, particularly the darker sorts of pigment. For instance, I have noticed that in killing the beautifully variegated Glossiphonia parasitica with this fluid, the green and brown spots often disappear entirely; while the yellow and orange spots remain conspicuous. This quality is sometimes an advantage, sometimes a disadvantage. If one wishes to preserve the color-pattern unimpaired, he would do well to use a fluid containing picric acid, which seems to have the property of fixing the pigment; or, better still, use formaldehyde both as the killing and as the preserving fluid.

Flemming's fluid is perhaps, on the whole, the best fixing fluid to use in preparing sections; corrosive sublimate is also good; Perenyi's fluid is for this purpose not to be recommended, except for the study of the gross anatomy of the central nervous system, which it makes very clear by bringing out nerves and fibre tracts in strong contrast to their connective-tissue sheaths.

Iron hæmatoxylin is the best stain which I have tried for sections. For whole preparations, animals should be heavily stained with carmine and then pretty thoroughly decolorized. I find Mayer's hydrochloric acid carmine (70% alcoholic) very convenient and serviceable, as it stains powerfully and there is no danger of maceration of tissues, however long the stain is allowed to act.

Decolorizing is best done with alcohol pretty strongly acidulated, as greater contrasts are thus obtained. I use 1% hydrochloric acid in 70%

[1] This method of stupefaction is also very useful in the study of the living animal, for the leech may be kept entirely motionless in the carbonated water within a live-box for hours, and then be revived by placing it again in fresh water.

alcohol, allowing it to act until the specimens have a light rose color, then wash well in neutral alcohol (90%), clear in cedar oil, and mount in balsam.

III. CLASSIFICATION.

Leeches of the family Rhynchobdellidæ may be distinguished from all others by the fact that they possess an exsertile proboscis (*pr'b.*, Figure 1), with the aid of which they obtain their food, for they are entirely without jaws such as the medicinal leech possesses. Our common North American species of this family belong to the genus Glossiphonia Johnson ('16), better known to many by its synonym Clepsine Savigny ('20). Leeches of this genus have usually a broad flat body, which, when the animal is disturbed, is rolled into a ball. Each somite consists typically of three distinct rings; but the somites at the ends of the body always contain a smaller number of rings.

These leeches are found in the shallow water of ponds and rivers underneath stones, sticks, or leaves, or adhering to the bodies of their hosts. The smaller species feed upon snails, crustacea, or other small fresh-water animals; the larger species are known to feed upon turtles, to whose shells they are often found attached. They probably suck the blood of other aquatic animals also.

The following key may aid in distinguishing the species to be described: —

Key to Species.

A. Crop diverticula a single pair (after a full meal the animal may have five more pairs, inconspicuous, and situated anterior to the principal pair); male and female genital pores separated by a single body ring; rings without metameric markings in the living animal.

1. Eyes two, distinct; a conspicuous yellowish brown chitinous spot on the neck dorsally . . . . *G. stagnalis* (p. 21)

2. Eyes two, inconspicuously pigmented or entirely without pigment; no chitinous spot on the neck; body extremely slender and transparent . . . . *G. elongata* (p. 39)

B. Crop diverticula six pairs; male and female genital pores separated by a single body ring or else united.

3. Eyes two, the middle (sensory) ring of each somite marked throughout the greater part of the body by a transverse row of whitish spots . . . . *G. fusca* (p. 34)

4. Eyes six, the first pair small and close together, the others farther apart; rings without metameric markings, or with dark pigment on the *anterior* ring of each somite.

G. heteroclita (p. 42)

C. Crop diverticula seven pairs; male and female genital pores separated by two body rings.

5. Eyes six, distinct, in two parallel rows; a conspicuous longitudinal band of dark pigment on either side of the median plane dorsally, and a fainter one ventrally; inconspicuous papillæ on the dorsal surface . . . . *G. elegans* (p. 46)

6. Eyes apparently a single pair, far forward on the head and confluent; back distinctly papillose. A large species, often found on turtles . . . . *G. parasitica* (p. 51)

IV. DESCRIPTION OF SPECIES.

1. Glossiphonia stagnalis Linnæus (1758).

Plate 1, Figs. 1, 3; Plate 2, Fig. 4; Plate 3, Figs. 7-10, 12; Plate 8, Fig. 34.

Hirudo stagnalis Linnæus (**1758**); H. bioculata O. F. Müller (**1774**); Clepsine bioculata Savigny (**'20**); C. modesta Verrill (**'72**); C. submodesta Nicholson (**'73**).

a. Habitat, Form, Size, Color.

This species is found in Europe, the adjacent parts of Asia and Africa, and in North and South America. As one might expect in the case of so cosmopolitan a form, much has been written about it, but its external morphology has never been carefully and accurately analyzed, and published accounts of its internal anatomy contain a number of errors or omissions, some of which I hope to rectify.

The general form of the body as seen in dorsal view, when partially extended, is shown in Figures 1 and 4. The body is broadest posterior to its middle and thence tapers gradually toward both ends. The head, which is only slightly wider than the neck, is evenly rounded in front (Figure 3); dorso-ventrally the body is very much flattened, especially when at rest. The animal is very active in its movements and can greatly elongate its body so as to become more than ten times as long as it is broad. The largest individuals measure as follows: —

Length, fully extended, 20–25 mm.; at rest, 8–10 mm.

Width, fully extended, about 2 mm.; at rest, about 5 mm.

Color, flesh-color or grayish. Small individuals are usually quite clear and transparent, but larger ones are apt to be more or less opaque. This opacity, as well as the general grayish tint which the body often has, is due to the presence in varying proportions of two different sorts of pigment cells. Those of one kind, which might properly be called reserve-food cells, may be found in the deeper parts of the body of all well-nourished individuals. They are large rounded cells, with an excentrically placed nucleus, their cytoplasm being filled with rounded, highly refractive granules often nearly as large as the nucleus. By reflected light these granules appear of an orange-brown color. Osmic acid browns slightly, but does not blacken them. Corrosive-acetic or picro-nitric mixtures make their composite nature apparent. An outer shell of darker, brownish substance appears surrounding usually one, sometimes two or three perfectly clear spherical inclusions. Perenyi's fluid, which is very strong in nitric acid, if allowed to act for about an hour, destroys almost every trace of the granules, the outer shell being the last part to disappear. Absolute alcohol acts in a similar way, but more slowly.

Graf ('99) has figured the granules accurately (see his Figures 87 and 102), but interprets their structure somewhat differently, regarding the clear portions as cavities; hence he speaks of the granules containing them as ring-shaped structures.

I at first supposed the clear portion to be a central core unaffected by the killing fluid, but abandoned this idea when I discovered two or more of them in different parts of the same granule. It seems to me that the outer part of the granule, which possibly contains some fatty material, as the osmic acid test indicates, is laid down upon a central core of a different substance which dissolves much more readily in acid solutions. So much my preparations indicate, but do not prove conclusively. Further study should be given to these interesting structures, doubtless a reserve-food product, which reminds one of the structures found in the seed of the Castor-oil Bean (Ricinus).

The second sort of pigment cell found in this species belongs to Graf's ('99) category of "excretophores." They occupy a superficial position in, or just under, the epidermis, and are slender, thread-like, branched (structures) of a dark-brown color. They are especially abundant in animals which have been kept for some time in well-lighted aquaria. Graf believes that pigment cells of this sort become detached as leucocytes from the wall of the body cavity, take up excretory products in the deeper parts of the body, especially in the neighborhood of the blood vessels, and then by amœboid movements make their way to the surface of the body, there to disintegrate.

b. Rings, Somites, Eyes.

External rings, rounded and distinct; sixty-seven in number, counting two narrow rings at the posterior end of the body (*64* and *66*, Figure 4, Plate 2).

Somites, thirty-four, as in all species of Glossiphonia. Somites VI.–XXIV., triannulate (Figure 4); all other somites show more or less abbreviation.[1]

[1] Throughout the descriptive part of this paper I shall speak of those somites which contain fewer than three distinct rings as "abbreviated" or "reduced." I

Somites I. and II. are together represented by a single broad ring (Figures 3, 4), which, however, is sometimes subdivided by a shallow furrow (Figure 7, Plate **3**).

. Somites III. and IV. consist each of a single ring, the latter forming the posterior boundary of the oral sucker (Figure 3, Plate **1**; Figure 7, Plate **3**).

Somites XXV. and XXVI. consist each of two rings, a broad followed by a narrow one (*63* and *64*, *65* and *66*, Figure 4, Plate **2**; Figure 34, Plate **8**). The narrow ring of somite XXVI., however, is often so completely fused with the broader ring which precedes it as to be scarcely distinguishable.

Somite XXVII. consists of a single broad ring, crowded back to a position lateral and posterior to the anus (*67*, Figures 4, 34, and *A*).

Somites XXVIII.–XXXIV. are not represented by external rings; in the central nervous system, however, we shall find clear evidence of their separate existence. A further discussion of the metamerism will be deferred until the nervous system has been described.

Eyes, two, large and distinct, lying in the anterior part of ring 3 and extending forward into the posterior part of ring 2 (Figures 4, 7).[1]

c. Dorsal Gland, Suckers.

Dorsal Gland. — Between the twelfth and thirteenth rings (that is, between the anterior and middle rings of somite VIII.) on the mid-dorsal surface of the animal, is a structure (*gl. d.*, Figures 4, 7) peculiar to this species, though according to Apáthy ('**88**[a]) its homologue is found in some other species, either as a functional structure in the embryo, or as an inconspicuous rudiment in the adult. It consists of a rounded, wart-like, yellowish-brown, cuticular plate, often surrounded by a ring of substance similar but lighter in color, probably because less well hardened. These structures are secreted by a patch of high columnar epidermal cells, which in the embryo, according to Apáthy, form a sort of byssus gland serving to attach the young to the under side of the mother before the suckers at the ends of the body become functional. In the adult the organ has no known function, though it forms a favorite place of attachment for a certain colonial protozoön of the genus Epistylis.

do so, however, without feeling at all certain that the terms are strictly applicable in all cases or even in a majority of cases. I have elsewhere (Castle, **1900**) expressed the opinion that the leech somite consisted primitively of a single ring. If this is so, it may well be that the somites commonly spoken of as abbreviated have really never *attained* the triannulate condition. (Moore, **1900**, has expressed a similar view since this paragraph was written.) Nevertheless the term is a convenient one to express deviation from the typical condition of the somite in the direction of a shortening of it. In this sense the term will be employed in this paper.

[1] Budge ('**49**) likewise represents the eyes in the anterior part of ring 3. Apáthy ('**88**[a]), however, counts the ocular ring the fifth, emphasizing subdivisions which can occasionally be seen in the most anterior rings. (Compare his Figures 4 and 10 with my Figures 3 and 7.)

The *oral sucker* (*suc. or.*, Figure 7) lies on the ventral side of the head, within the limits of rings 1–3 (somites I.–IV.).

The *mouth* (*or.*, Figure 7) opens anterior to the middle of the oral sucker as well as anterior to the eyes.

The *posterior sucker* (*act.*, Figures 1, 4), also ventral in position, is slightly longer than broad. Average dimensions for the largest individuals are: — length, 1.31 mm.; width, 1.24 mm.

d. Reproductive Organs.

The *male genital pore* (*po.* ♂, Figure 4) lies in a mid-ventral position between rings 24 and 25; that is, between the anterior and middle rings of somite XII.

The *female genital pore* (*po.* ♀, Figure 4), which is a broad transverse slit, lies just one ring behind the male pore, between rings 25 and 26, the middle and posterior rings of somite XII.[1]

Testes (Figure 4, *te.*), six pairs, placed intersegmentally in somites $\frac{\text{XIII.}}{\text{XIV.}}-\frac{\text{XVIII.}}{\text{XIX.}}$. The size and appearance of the testes vary considerably with the seasons. In the fall and early spring they are generally large and their outlines more or less irregular, for they adapt themselves to the spaces left them among the dorso-ventral muscles and other deep-lying organs. The testis wall is quite thick on its dorsal, ventral, and lateral aspects, but somewhat thinner on its median aspect. It is lined with a loose germinal epithelium of spindle-shaped cells, except at its dorso-median angle, where there is a small patch of ciliated epithelium continuous with that of the vas efferens.

Male genital ducts. — The vas efferens is a short, delicate tube, which leads dorsad and cephalad to join a longitudinal duct similar in structure to itself and only slightly larger, the proximal or collecting part of the vas deferens (Figure 4, *va. df.*). Anterior to the first pair of testes, that is, about on the border between somites XII. and XIII., the collecting portion of the vas deferens bends sharply toward the median plane of the body and passes between the strong dorso-ventral muscles, which, like a row of pillars, mark off on each side the

[1] I am unable to find in any published account an explicit statement as to the position of the genital pores in this species. Budge ('49) figures the male pore in the posterior third of ring 25 and says, "Gegen den 25 Ring findet sich die sehr feine männliche Geschlechtsöffnung." He does not figure the female pore, but says (p. 100), "Ungefähr am 27. Leibesringe die äussere [female] Geschlechtsöffnung liegt." This would make the genital pores distant from each other *about* two rings, which, however, is incorrect.

Ludwig ('86) incorrectly describes the position of the genital pores for the entire genus "Clepsine" as follows (p. 781) "männliche Geschlechtsöffnung zwischen dem 25. und 26., weibliche zwischen dem 27. und 28. Ringel." This statement rests upon two erroneous assumptions, first, that the number of distinct rings is the same in the head region of all species, and, secondly, that the genital pores are always two rings apart. In only two of the six species described in this paper are the genital pores separated by two rings.

lateral limits of the median lacunar space. This space the vas deferens enters in company with the ducts of the salivary glands, which here pass inward to join the base of the proboscis (Figure 1, *gl. sal.*) Having reached the median lacuna, the vas deferens turns backward, running usually ventral and lateral to the digestive tube and parallel with the course of its collecting portion. In the median lacuna it winds about more or less, or may even cross into the opposite half of the body as a result of its being crowded for room either because of its own distended condition or from the condition of other organs in its vicinity. As it runs backward it widens into a spacious seminal vesicle (Figure 4, *vs. sem.*), and its epithelial lining ceases to be ciliated. The dimensions of the seminal vesicles vary with the amount of sperm stored in them, being capable apparently of great enlargement. Sometimes the vesicle runs back as far as the pair of long crop diverticula in somite XIX. (Figure 1), and is crowded out in the form of one or more loops between the testes (Figure 4); it may even find room for itself by crossing into the opposite half of the body. Ultimately it bends forward again and, narrowing, continues as the muscular and glandular ejaculatory duct (Figure 4, *dt. ej.*). The ejaculatory duct, as it runs forward, passes outside of the inner row of dorso-ventral muscles at about the point where the collecting portion of the vas deferens enters the median lacuna. It then runs forward into somite XI., where, turning sharply back again, it expands into a thick-walled "terminal horn," which, uniting with the terminal horn of the other half of the body, opens to the outside by the mid-ventral male genital pore (*po.* ♂, Figure 4). The special function of the ejaculatory duct and particularly of its terminal horn, Whitman ('91) has shown to be the formation and extrusion of the spermatophore.

In the early spring, as the water in the ponds begins to grow warmer, the seminal vesicles are seen to be gorged with sperm, and the formation of spermatophores takes place rapidly. These the animals attach to one another's backs. Whitman ('91) has shown that in the case of G. parasitica ("Clepsine plana") the contents of the spermatophore pass through the integument into the body cavity, and that impregnation probably occurs while the egg is still in the ovary. A similar process doubtless occurs in the case of G. stagnalis.

After the period of active spermatophore formation has passed, — it ordinarily lasts but a few days or weeks, depending upon the rapidity with which the temperature of the water rises, — the vasa deferentia are seen to be greatly reduced in size and the testes quite inconspicuous, though in the fall they were the most conspicuous organ in the entire body.

The *ovaries* (Figure 4, *oa.*) are a pair of simple sacs extending back from the female genital pore in the median lacuna, usually ventral and lateral to the digestive tube. They are attached more or less loosely by mesenterial strands of connective tissue to those portions of the vasa deferentia which lie in the median lacuna. This connection, however, is so slight that when crowded for room an ovary may extend out in loops between the testes, or across into the opposite half of the body, just as the vasa deferentia do. The size of the ovaries depends upon the state of maturity of the contained ova. They are largest in the early spring immediately before the eggs are laid, when they often extend the whole length of the genital region and are looped or folded, as are the seminal vesicles; they are smallest immediately after the egg-laying. A mean between these two extreme conditions is shown in Figure 4.

The time of egg-laying, as well as of spermatophore formation, depends upon the warming of the water in the spring. One can hasten both processes by bringing the animals for a few days into a heated room. Around Cambridge the eggs are laid mostly in the months of April and May. Small-sized individuals, however, may come to maturity later in the season, even as late as September.

The eggs are pink in color and about 0.3 mm. in diameter. They are attached to the under surface of the body in groups of two to eight eggs each. Each group is enclosed in a separate, delicate, transparent sac, which adheres to the under surface of the body. The sacs are arranged in two longitudinal rows close together, one on either side of the median plane of the body. The more posteriorly placed sacs usually contain more eggs than those farther forward.

I have not observed the process of egg-laying, but believe that the eggs of a single sac are laid at about the same time, that they are then crowded back as far as possible under the body, and that there is poured over them a secretion from the clitellar glands which hardens into the delicate wall of the sac. After a period of rest, during which the body is closely applied to the group of eggs so that its sac becomes fastened to the body, another group of eggs is laid, and so on until all the mature eggs have been expelled from the ovary. The clitellar glands are deep-seated, unicellular epidermal glands opening on the ventral surface in the vicinity of the female genital pore. They can be demonstrated by methylen-blue staining.

Animals which are kept in aquaria lay their eggs at night, and always complete the process in a single night, so that all the eggs borne by an individual are in about the same stage of development at one time.

I think it probable that the egg sacs are arranged in the order laid, from behind forward, for in one of the most anterior sacs a single egg is occasionally found, but never in one of the more posterior sacs have I observed so small a number. The number of eggs laid by an individual depends upon its size. An animal thirteen mm. long (when fully extended) was found to have laid sixteen eggs; another twenty-six mm. long was found carrying forty-five eggs. The average number for nine individuals examined at one time was thirty-one.

The usual number of egg sacs formed is six or eight; in one case examined it was ten. The average number of eggs found in a sac is about four; for the most anterior pair of sacs it is three.

e. Digestive Tract.

The position of the *mouth* (*or*, Figures 3, 7), except when the body is much contracted, is anterior to the eyes, in the third somite (ring 2).

It leads dorsally into the *pharyngeal sac* (*sac. phy.*, Figure 7), which continues backward through the brain mass, ending in somite XIII. (Figure 1). Within the pharyngeal sac lies the *proboscis* (*pr'b.*, Figure 1), which, in a state of rest, usually extends from a point just behind the brain back into somite XIII., where the ducts of the *salivary glands* enter its walls. These glands (*gl. sal.*, Figure 1) are a conspicuous feature of a Glossiphonia differentially stained. They are always unicellular, and represent the largest cells found in the body except certain nephridial cells and eggs approaching maturity. The salivary gland cells have a great avidity for stains. They number in this species thirty or more in each half of the body, and are found scattered through about three somites (XII.–XIV.). The largest gland cells are those most remote from the base of the proboscis. Each cell has a separate slender duct leading into the wall of the proboscis and opening into the lumen of that organ at some point along its length.

A short slender *œsophagus* (*œ.*, Figure 1), ordinarily lying entirely within somite XIII., connects the base of the proboscis with the *crop* (*i'glv.*, Figure 1). This readily distensible part of the digestive tract extends over six somites (XIV.–XIX., Figure 1). *Under ordinary circumstances it has but a single pair of lateral diverticula;* these arise in somite XIX. and extend backward, usually ending in somite XXI. After a full meal, however, short lateral diverticula may sometimes be seen also in the five more anterior somites (XIV.–XVIII.), but this condition appears always to be a transient one.

The *stomach* (*ga.*, Figure 1) begins in somite XX. and ends in somite XXIII. It bears four pairs of persistent lateral diverticula doubtless originally segmental in origin, but now crowded within the limits of about three somites. The first two pairs of stomach diverticula are directed forward, the last pair backward; the third pair lies about at right angles to the long axis of the body.

The terminal part of the digestive tract, the *intestine* (*in.*, Figure 1), is a gradually narrowing tube; it includes one or two proximal chambers separated from the following part by constrictions.

The anus is dorsal in position, as in all other leeches, and lies within or just behind somite XXVII. (Figure *A*, page 32; Figure 34, Plate 8). Comparison with other species, in which the reduction of somites is less extensive, shows that primitively the anus lay *behind* somite XXVII.

f. Nephridia.

The nephridia number at least sixteen pairs, possibly seventeen pairs. The nephropores (*nph'po.*, Figure 4) lie on the ventral surface of the body, somewhat nearer the margin than the median plane, and almost exactly in the middle of their respective rings. The nephropores are always found in this genus on the middle ring of a somite. I have found them in sections of G. stagnalis in somites VIII.–XXIV., with the single exception of somite XIII. (ring 28). The strong development of the salivary glands in this region may account for the possible disappearance of the pair of nephridia which we should expect to find here.

g. Nervous System.

The central nervous system, as in other leeches, consists in the middle part of the body of a ventral ganglionic chain of twenty-one distinct ganglia metamerically arranged and joined by paired connectives. Forming an extension of this ganglionic chain at either end of the body, one finds a nervous mass representing several primitively distinct ganglia more or less intimately fused together. In the central part of the body the ordinary position of the nerve ganglion is in the middle ring of its somite (Figure 4, somites XII.–XVIII.). Toward either end of the body, however, there is a slight, but increasing, centripetal displacement of the ganglia, just as is frequently the case in the central nervous system of Arthropoda. This displacement may amount to as much as two-thirds of a somite, or in extreme cases an entire somite. Thus we see in Figure 4 that the ganglion of somite VII. lies in the first ring of somite VIII., a displacement of two rings; in somites VIII.–XI. the displacement is only a single ring. About the same amount of displacement occurs in somites XIX.–XXII.; in somites XXIII. and XXIV. it amounts to about two rings; and in somites XXV.–XXVII. it is still greater. The positions in which the nerve ganglia are shown in Figure 4 are average ones carefully computed from the observed positions in five different individuals. The ganglia are very constant in position, the extreme variations usually amounting to only a fraction of the width of a ring.

The structure and morphological value of the ganglionic masses at the two ends of the body is a subject closely connected with the general question of the metamerism of the body.

h. Metamerism.

(1) *Number of Somites.*

A number of investigators have discussed the question of how many somites are found in the body of a leech, and have reached conclusions varying according as they placed emphasis on one or another of the following criteria: (1) The number of external rings; (2) color markings of rings, or the recurrence of peculiar papillæ on certain rings of each somite; (3) metameric sense organs; (4) the number of ganglia in the central nervous system as determined (*a*) by a count of the nerve capsules, typically six to a ganglion, or (*b*) by ascertaining the number and peripheral distribution of the nerves arising from the ganglia.

Whitman ('**92**), making use principally of the criteria named under 3 and 4, was the first to obtain an entirely satisfactory answer to the question. He has shown that in the central nervous system of "Clepsine hollensis" (which is closely related to G. parasitica) there are present thirty-four ganglia, each giving off paired nerves. Six of these ganglia are found in the anterior ganglionic mass which encircles the pharyngeal sac; seven are found in the posterior ganglionic mass which lies in the posterior sucker and supplies it with nerves; these, added to the twenty-one distinct ganglia found in the central part of the body, bring the total up to thirty-four. An examination of the sense organs connected with these ganglia, and situated typically on the middle ring (first, Whitman) of each somite, yields corroborative evidence that the number of somites represented in the body is thirty-four.

Bristol ('99) subsequently made a similar study of the metamerism of Nephelis lateralis, his conclusions being for the Gnathobdellidæ entirely in harmony with those of Whitman for the Rhynchobdellidæ.

Oka ('94), however, has cast doubt upon the general applicability of Whitman's determination, based as it was on the metamerism of a single species of Glossiphonia, by stating that in the several European species which he has studied (G. stagnalis, G. complanata, G. concolor, G. heteroclita, G. papillosa, G. marginata, and G. tessellata) he finds evidence of *only five* (not of six) fused ganglia in the brain. Moreover, in recent systematic papers, such as those of Blanchard ('94) and Moore ('99), we find the body of the leech still analyzed and described as consisting of twenty-six preanal somites, instead of twenty-seven, the number found in that portion of the body by Whitman ('92) and Bristol ('99), and still earlier, though on less satisfactory evidence, by Apáthy ('88).

Accordingly, I have thought it worth while to examine into this matter rather carefully in the case of the species studied by me.

I may say at once that my results, in the case of all six species studied, are in complete accord with those of Whitman ('92), so far as the *number* of metameres is concerned. In determining the *limits* of the somite, I have arrived at conclusions differing from those of my predecessors, as will presently appear (p. 31 ff.).

a. Structure of a Typical Ganglion. — A typical ganglion from the middle of the body has its ganglion cells arranged in six groups enclosed in capsules of connective tissue. Four of these capsules are lateral in position, two on each side of the ganglion; the other two occupy a mid ventral position, one in the anterior, the other in the posterior part of the ganglion. (See the ganglion of somite XXVI. in Figure 9, Plate 3.) Three nerves are given off close together from either side of the ganglion, and are distributed to the three successive rings of one and the same somite, as I have elsewhere (Castle, 1900) pointed out.

If, then, we can determine exactly how many such ganglia are present in the central nervous system of a leech, we shall be in a position to say how many somites enter into the composition of its body.

In the middle part of the body, as already stated, twenty-one distinct ganglia of the sort just described can easily be recognized. To determine how many are present toward either end of the body, where more or less fusion of ganglia has taken place, is a matter of more difficulty.

β. Fused Ganglia. — Figure 9 (Plate 3) shows a dorsal view of the posterior part of the central nervous system of G. stagnalis, obtained by reconstruction from a series of frontal sections. The last two distinct ganglia, those of somites XXVI. and XXVII., are shown, followed by the nerve mass of the posterior sucker, made up of seven fused ganglia. In it seven pairs of lateral capsules appear on either side, a segmental nerve root being closely connected with each pair (XXVIII.–XXXIV.). The more posterior of the lateral capsules has in the case of each pair been displaced outward and downward (ventrad) and been reduced in size. The position of the seven pairs of ventral capsules is indicated by dotted outlines, the numeral denoting the somite to which each capsule belongs. In the first and last of the fused ganglia of this region, the ventral capsules occupy their typical tandem position (as in ganglion 26); in the case of the intervening ganglia (29–33), we find a more or less complete displacement of the ventral capsules to a side-by-side position. A similar displacement occurs in ganglion 27, which lies close back against the septum which divides the lacunar space of the posterior sucker from that in which the more anterior portions of the central nervous system lie. The same mechanical cause, crowding in an antero-posterior direction, explains both phenomena of displacement.

The evidence presented in Figure 9 leaves no room for doubt that seven primitive ganglia are found in the nerve mass of the posterior sucker in this species. Determination of the number of ganglia represented in the brain mass is not quite so easy, but the evidence is likewise convincing. The brain (*b.*, Figures 4, 7) forms a ring of nervous substance situated commonly in the last ring of somite VI. and the first two rings of somite VII. It surrounds the thin-walled pharyngeal sac (*sac. phy.*, Figure 1), there being in leeches no recognizable separation into supra- and sub-œsophageal ganglia.

A lateral view of the brain and the metameric nerves given off from it is shown in Figure 8; a view of its dorsal surface in Figure 12. Figure 10 shows the arrangement of the capsules on its ventral surface. An examination of Figures 8 and 10 shows that the capsules (*6*, *6*) of the last brain ganglion have quite their typical arrangement. A triple segmental nerve (VI., Figure 8) emerges from under a pair of lateral capsules, while below a pair of ventral capsules are arranged in the usual tandem order (*6*, *6*, Figures 8, 10).[1]

Ganglia 3–5 likewise present no special difficulties, their lateral capsules being present in pairs with nerve roots attached (*3*, *3*; *4*, *4*; *5*, *5*, Figure 8).

[1] I have been unable to determine to what extent in the reduced somites at the two ends of the body the original triple nature of the segmental nerves persists. The nerve of the last brain ganglion is certainly triple (VI., Figure 8), as we should expect from the fact that somite VI. consists of three distinct rings (Figures 4, 7). Most of the nerves anterior to this one, perhaps all, are either double or triple, but as I have been unable to determine accurately which condition exists in some of them, I represent the nerve as undivided in the case of the first five somites (Figure 8). For a like reason I follow a similar course in representing the segmental nerves of the posterior ganglionic mass (Figure 9). I think that all of these nerves are made up of at least two distinct bundles of fibres; whether the small third nerve is also present as a distinct element in any or all of them, I am unable at present to say.

Their ventral capsules show the following modification in arrangement; they have been displaced from the typical tandem position to a side-by-side position (Figures 8, 10; compare Figure 9, somites XXIX.–XXXIII.).

The lateral capsules of ganglion No. 2 are found dorsal to the pharyngeal sac (*2*, *2*, Figures 8, 12). They seem to have been displaced backward to a position somewhat posterior to the lateral capsules of ganglion No. 3 by a migration in that direction of the supra-œsophageal commissure (Figure 8; compare Figures 11, 21). The commissure in this species is normally thrust back of the position in which it is shown in Figure 8, so that it lies about over the lateral capsules of ganglion No. 5. The animal whose brain is represented in Figure 8 was curved ventrad so that the commissure was thrust forward of its usual position and the row of lateral capsules below it was straightened out a little. The position of the ventral capsules of ganglion No. 2 is shown in Figures 8 and 10; the nerve root (II., Figure 8) arises at the anterior end of the brain just ventral to nerve root I.

The ganglionic capsules of neuromere No. 1 *all* lie dorsal to the pharyngeal sac and anterior to the supra-œsophageal commissure (Figures 8, 12). I believe that the most anterior and ventral of these (I *v*., Figures 8, 12), which lies closely attached to nerve root I. in each half of the body, is homologous with a ventral capsule of one of the succeeding ganglia. Capsule I *v*. extends out lateral to, sometimes even ventral to, nerve root I., so that its end may appear in sections between nerve roots I. and II.

Oka ('94) states that he finds in the brain of "Clepsine" (Glossiphonia) always *thirty* nerve capsules, and he accordingly regards it as equivalent to *five* fused ganglia and no more. Since G. stagnalis was one of the species studied by him, I am unable to understand how he can have reached such a conclusion, unless he has overlooked altogether the capsules of somite I. which lie *anterior* to the supra-œsophageal commissure.

Both the number and arrangement of the nerve capsules, and the number and position of the nerve roots, show clearly that in G. stagnalis SIX *fused ganglia are represented in the brain, and that in the entire body* THIRTY-FOUR *somites are represented.*

(2) *Somite Limits.*

It remains to explain the grounds on which the limits of the somites have been placed by me as indicated in Figure 4. Whitman ('85) pointed out many years ago that a certain ring (the first, according to his account) of each typical somite in the body of a leech is more richly supplied with sensory organs ("sensillæ") than any other ring of the somite. In many species of Glossiphonia special color markings or papillæ are also found on the sensory ring. Color markings, however, are wanting in G. stagnalis, and the sensillæ are not sufficiently conspicuous in the living animal to make identification of the sensory rings at all certain. But a carmine stain of the proper intensity renders identification of the sensory rings quite easy by giving them, especially along the margins of the body, a somewhat darker color. Observing this fact, I was first enabled to determine as sensory the rings indicated by Arabic numerals in the right half of Figure 4; further study revealed the presence of marginal sensillæ in the positions indicated in Figure 3.

The metamerically repeated sensory annuli were thus positively identified throughout the greater part of the body. It remained merely to mark off the somite limits between successive sensory annuli. This I at first did after the usage of Whitman ('85, '92) and practically all others since the time of Gratiolet ('62), considering the sensory ring as occurring *at the anterior end of its somite.*

I found, however, that a consistent following of this practice would, toward either end of the body, place the somite limits *in the middle of a ring* instead of between rings, the position in which somite boundaries fall in other regions of the body. See Figure *A*, XXV′., XXVI′., etc.

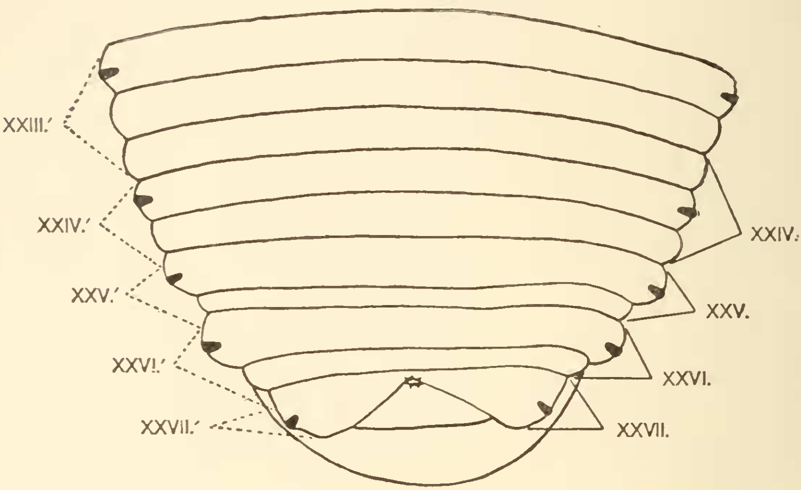

FIGURE *A*. — *G. stagnalis.* Dorsal view of posterior part of body, showing marginal sensillæ. Somite limits are indicated correctly at the right of the figure (XXIV. to XXVII.); at the left of the figure (XXIII′. to XXVII′.) they are shown as they have been commonly but incorrectly placed.

This led me to inquire whether the sensory ring really is the anterior ring of its somite. The results of this inquiry have been published elsewhere (Castle, 1900), so that only one or two of the more important conclusions need be restated here. One of these, already suggested in part on page 29, is the following: —

Somite limits coincide with neuromeric limits; consequently in Glossiphonia the sensory ring is the middle, not the anterior ring of the somite.

This point being established, the somite limits must be marked off, in the regions where unabbreviated somites occur, as in Figure 4, VI.–XXIV.

I have further shown, in the publication already cited, that in Glossiphonia somite abbreviation[1] is accomplished by a series of steps which follow one another in regular sequence. First, a union takes place between the sensory ring and the ring which precedes it; secondly, the ring which follows the sensory ring is reduced in size; finally, it too fuses with the sensory ring, the entire somite being then represented by a single external ring.

If, as is not improbable, some of the "abbreviated" somites are really in arrested stages of development from the one-ringed to the three-ringed condition (as suggested in the case of Microbdella by Moore, **1900**), the order of the three steps enumerated should be reversed, in their case, and described in the following terms: (1) A distinct narrow ring is separated off at the posterior end of the uniannulate somite; (2) this newly formed posterior ring grows in width; (3) another new ring is separated off at the *anterior* end of the somite. This produces a three-ringed somite, all three rings ultimately attaining an equal width. For convenience in description, however, the process will be uniformly treated as one of abbreviation, as explained on page 22, footnote.

The amount of "abbreviation," as is well known, becomes greater toward either end of the body.

Bearing in mind these principles, we find that the least affected of the abbreviated somites of G. stagnalis are those which stand nearest to the unabbreviated somites, namely, V. (Figure 3) at the anterior end of the body, and XXV. (Figure *A*) at the posterior end. In the case of each of these, the anterior and sensory rings of the somite are united into a single broad ring. But in the case of somite V. we find the union occasionally incomplete, as indicated by the notch (less clearly than it should be) at the upper margin of Figure 3, ring 4.

Somite XXVI. (Figure *A*; Figure 34, Plate **8**) is usually found in the same condition of abbreviation as the somites just described. Occasionally, however, its posterior ring is narrower or less distinct than that of somite XXV.

In somites III. and IV. the process of abbreviation to a single broad ring is practically complete, although the narrow posterior ring is in favorable preparations still recognizable as a distinct element separated from the rest of the somite by a shallow transverse furrow (Figure 7, III., IV.).

Somites I., II., and XXVII. have each been reduced to a single ring; in addition a fusion (sometimes incomplete) has taken place between somites I. and II., so that they are together represented by the broad ring, 1 (Figure 7).

Somites XXVIII.–XXXIV. are not represented by annuli on the surface of the body; they form collectively the posterior sucker.

[1] As to the sense in which this term is used, see p. 22, footnote.

2. Glossiphonia fusca sp. nov.

Plate 4.

a. Habitat, Form, Size, Color.

This species is rather closely related structurally to G. stagnalis, with which I have found it associated in the vicinity of Cambridge, Mass., and Trenton, New Jersey. It is of about the same size as G. stagnalis, but is broader in proportion to its length (Figure 13, Plate **4**). In its movements it is somewhat more sluggish than that species and does not stretch itself to so great a length.

Length of largest individuals, fully extended, 20 mm.; at rest, 9 mm.

Greatest width, when fully extended, 2.5 mm.; at rest, 4 mm.

Color, a coffee-brown above, somewhat lighter below. The general brown coloration is due to the presence in the superficial layers of the body of slender, branched, thread-like pigment cells bearing numerous knot-like swellings and filled with a dark-brown pigment. Such pigment cells are clearly homologous with the pigment cells found in a superficial position in the body of G. stagnalis, — Graf's "excretophores." They are much more abundant on the dorsal than on the ventral surface. On the former they appear in greatest numbers in a median dark band about as wide as two or three body rings; but they are entirely wanting anterior to the eyes and in the following regions, which therefore appear as clear, transparent areas: —

1. A transverse row of circular spots found on the sensory ring of each somite. These spots are about the width of a ring in diameter. Their maximum number is seven, but it is a rare occurrence to find all seven present in a single somite. Each spot occupies a definite position on its ring, so that those of successive somites form seven longitudinal rows, three in each half of the body and one median in position. The paired rows may be designated as *marginal*, *intermediate*, and *paramedian*, for they occupy positions which correspond closely with those of the rows of dorsal papillæ so designated in the case of G. parasitica (Plate **2**, Figure 6).

The paramedian rows of clear spots are more constant in occurrence than any of the others; they can usually be found on somites v.–xxvi. The intermediate and marginal rows usually begin about in the region of the genital pores and continue with increasing distinctness back to the anus. The median row is less well developed than any of the others. It is represented by an occasional clear spot in the region posterior to the genital pores and anterior to somite xxii.

2. In the region of somites xxii.–xxvi., the median row of clear spots is suddenly replaced by a continuous clear band about as wide as one of the spots. Along the margins of this clear band, the pigment is unusually abundant, which fact adds by contrast to the conspicuousness of the median band.

3. The margin of the posterior sucker, where it projects beyond the outline of the body as seen in dorsal view, usually bears eight or ten triangular or

rounded clear spots of approximately the same form and position as the yellow pigment spots found on the posterior sucker of G. parasitica (see stippling in Figure 6).

4. The sensory ring of each of the somites in the neck region — somite v. and a few of the following — is occasionally distinguished by an uninterrupted, but narrow, clear band, which runs entirely across it from one side of the body to the other, occupying about its middle third.

The conspicuousness of the unpigmented areas just described, except that mentioned under (4), is increased by the presence in the centre of each of a group of peculiar reserve-food cells, which lie quite near the surface of the body.

The *ordinary reserve-food cells* of this species agree in practically every particular of structure and distribution with those of G. stagnalis. They are large rounded cells, sometimes attaining a diameter of eighty mikra or more. The granules within their cytoplasm attain a diameter of six or seven mikra. The color of these cells by reflected light is a pale orange; by transmitted light, they are semi-transparent, of a leaden gray color. They are distributed irregularly through the middle and posterior portions of the body, being situated in its deeper parts.

The *special form of reserve-food cell*, which is found in the segmental clear spots already described, differs in respect both to size and to color from the ordinary reserve-food cell. It is considerably smaller, — forty to fifty mikra being the maximum diameter observed, — and its contained granules are likewise smaller, though more numerous. Its color by reflected light is a bright lemon yellow; by transmitted light it is brown. Finally this variety of reserve-food cell is invariably situated quite near the surface of the body. The appearance of a group of these cells as seen under a moderately high power of the microscope is shown imperfectly in Figure 17 (Plate 4).

The ventral surface of the body is pigmented in very much the same fashion as the dorsal, but less heavily. There is, however, this difference in the distribution of the superficial brown pigment: on the ventral surface a pair of narrow, paramedian, pigmented lines can be recognized, one in each half of the body, in about the position of those found both dorsally and ventrally in G. elegans (Figure 30, Plate 7). On the dorsal surface, on the other hand, the most heavily pigmented region is a broad median band (p. 34).

Segmental clear spots are found on the sensory rings on the ventral surface also, and these are arranged in paramedian, intermediate, or marginal rows; but the spots are much less conspicuous than on the dorsal surface, and the lemon-yellow reserve-food cells are less often found in their centres.

Comparing the coloration of this species with that of G. stagnalis, we may say that the histological elements which produce the coloration are very similar in the two, but the distribution of these elements is such as to produce in G. fusca a distinct color pattern (longitudinal striations and segmental clear spots), a feature entirely wanting in G. stagnalis.

b. Rings, Somites, Eyes, Suckers.

External rings, not quite so distinct as in G. stagnalis ; skin, slightly rougher owing to the stronger development of Bayer's ('96) sense organs. Number of preanal rings, seventy (Figure 13, Plate 4).

Somites v.–xxiv. are triannulate, but the two anterior rings of v. are united ventrally (Figure 15).

Somites i. and ii. are included in a single broad ring, which, just as in G. stagnalis, is sometimes subdivided by a shallow transverse furrow (Figure 14) marking the boundary between the two incompletely fused somites.

Somites iii., iv., xxv. and xxvi. (Figures 13–16) are biannulate. In each case the broader, anterior ring bears the sensillæ and corresponds to rings 1 and 2 of triannulate somites (compare somites iv. and v. of Figure 15).

Somite xxvii. is a single broad ring (70, Figure 13) which lies just anterior to the anus, not crowded back of it, as in stagnalis (Figure 34, Plate 8).

The principal differences in somite composition between fusca and stagnalis occur in the head region, in somites iii.–v. These somites are less abbreviated (or more fully elaborated) in fusca than in stagnalis, hence the greater number of preanal rings in the former (seventy) as compared with the latter (sixty-seven).

Eyes, two, large and distinct, situated in rings 3 and 4 (Figures 14–16). The sensory elements of each eye, as in G. stagnalis, are contained in a pigment cup which is open only on its anterior, lateral surface, where the nerve fibres make their exit (Figures 14, 16).

Oral sucker, as in all species of Glossiphonia, included within the first four somites (Figures 14, 15).

Posterior sucker of about the same dimensions as in G. stagnalis, slightly longer than broad.

c. Reproductive Organs.

Male genital pore (*po.* ♂, Figure 13), between the first and second rings of somite xii. (rings 27 and 28).

Female genital pore (*po.* ♀, Figure 13), between the second and third rings of somite xii. (rings 28 and 29).

Testes (*te.*, Figure 13), six pairs situated intersegmentally in somites $\frac{\text{xiii.}}{\text{xiv.}}$–$\frac{\text{xviii.}}{\text{xix.}}$

The *ovaries* have the usual form and position of these structures in other species, being found ventrally in the median lacuna.

Eggs are laid a month or six weeks later than by G. stagnalis (June 12, 1898, Cambridge, Mass.). In color they resemble those of G. stagnalis closely, being of a light pink or flesh color. As in G. stagnalis, the eggs are attached to the under side of the body posterior to the genital pores, within a number of delicate sacs arranged in two parallel rows, close together, one on each side of the median plane. The number of sacs is most often six, but a seventh sac was observed in one case. The number of eggs in a sac, as well as the total number of eggs laid by an individual, is greater in this species than in G. stagnalis. The following figures will indicate the number of eggs borne by four good-sized individuals, which laid eggs in the laboratory in June, 1898. The vertical line represents the median plane of the body; the positions of the numerals show how the sacs were placed with reference to one another and to the median plane of the body; the numerals themselves indicate how many eggs were in each sac. Anterior is toward the top of the page, and the right side of the body toward the left of the page, the animals having been observed in ventral view.

INDIVIDUAL I.

	a.		
	16	17	
r.	16	20	*l.*
	22	13	
	p.		

Total 54 + 50 = 104

INDIVIDUAL II.

	a.		
	11	6	
r.	15	13	*l.*
	18	14	
	p.		

44 + 33 = 77

INDIVIDUAL III.

	a.		
	2	13	
r.	18	20	*l.*
	19	18	
	p.		

39 + 51 = 90

INDIVIDUAL IV.

	a.		
		5	
	16	14	
r.	21	19	*l.*
	17	13	
	p.		

54 + 51 = 105

Average number of eggs in a sac in above cases, 15 (as against 4 in G. stagnalis); average number of eggs borne by an individual, 94 (as against about 30 in the case of G. stagnalis).

It will be noticed that one of the anterior sacs often contains a relatively small number of eggs (as noticed in the case of G. stagnalis also), suggesting that it served to finish off the egg-laying, the sacs being arranged in the order in which they were formed, from behind forward.

d. DIGESTIVE TRACT.

The *mouth* is situated anterior to the eyes, well forward in the anterior half of the oral sucker (Figures 14, 15). From here the thin-walled *pharyngeal sac* (*sac. phy.*, Figure 13) leads back to the base of the proboscis in somite XII., just behind the male genital pore. When the animal is at rest the *proboscis* (*pr'b.*, Figure 13) usually extends through the four somites between the brain and the male genital pore (VIII.–XI.) into somite XII., where it receives the ducts of the salivary glands, a bundle from either side of the body.

The *salivary glands* themselves are very large in this species and are distributed in the marginal part of the body through somites XI.–XVII., or, in exceptional cases, even a somite farther in one direction or the other.[1]

The short *œsophagus* (*œ.*, Figure 13) extends from the base of the proboscis through somite XIII. to the beginning of the crop in somite XIV.

The *crop* (*i'glv.*, Figure 13) extends over the six somites XIV.–XIX., giving off in the middle of each a pair of conspicuous lateral diverticula. *These are always evident whether the crop contains food or not*, a condition very different from that which exists in G. stagnalis. The last pair of crop diverticula (those of somite XIX.) are very long but simple, as in G. stagnalis, without secondary lateral diverticula. They extend back over the entire stomach region, usually ending in somite XXIII.

The *stomach* (*ga.*, Figure 13), which is separated from the crop by a valve-like constriction, bears four pairs of lateral diverticula doubtless originally metameric in arrangement, but now arising within the limits of somites XX.–XXII.

The *intestine* (*in.*, Figure 13) leads from the stomach back to the anus, which is situated dorsally just behind somite XXVII., as in other species of Glossiphonia. The intestine includes anteriorly two rather spacious chambers, the first of which bears a pair of small ear-like diverticula from its anterior lateral borders. Behind these chambers comes a simple tubular part terminating at the anus.

To sum up, *the particulars in which the digestive tract of G. fusca differs conspicuously from that of G. stagnalis are* (1) the shorter proboscis and larger œsophagus; (2) the larger salivary glands, distributed through a greater number of somites; (3) the persistent character of the first five pairs of crop diverticula; (4) the distinctly chambered condition of the intestine, and the pair of diverticula borne by its first chamber.

Nephropores are found on the sensory ring of each of the somites VIII.–XXIV., with the possible exception of XIII., where, as in stagnalis, the nephridia are much reduced, if not wholly wanting, — a fact accounted for by the strong development of the salivary glands and genital ducts in that region. The nephropore lies usually a little anterior to the middle of the ring on which it is found.

e. Nervous System.

A ventral view of the brain is shown in Figure 18, a dorsal view of that part of it which lies above the pharyngeal sac is shown in Figure 16, the position of the ventral part being indicated by a dotted line; the outline of the brain

[1] The animal shown in Figure 13 was a small one, and the salivary-gland cells are proportionally a little larger than they would be in the average, full-grown animal.

as seen in a lateral view is shown in Figure 14, *cb*. It lies for the most part in somites VII. and VIII. This is about a somite posterior to the usual position of the brain in G. stagnalis (Figures 4, 7).

The number of fused ganglia represented in the brain is, as in G. stagnalis, six, and the nerve capsules have the same general arrangement as in that species. The ventral capsules of neuromeres II.–V. are placed side by side, while those of neuromere VI. lie one behind the other (Figure 18; compare Figure 10, Plate 3). The six capsules of neuromere I. are situated well dorsal, as in G. stagnalis, and the supra-œsophageal connective is pushed back nearly over the middle of the entire brain mass (Figures 14, 16). The lateral capsules of neuromere II. are shown in the dorsal view (Figure 16); those of neuromeres III.–VI., in the ventral view (Figure 18).

In Figure 14, which represents a parasagittal section, is shown the position of the paramedian sensillæ of the head somites, certain of which also appear in Figure 15. These indicate clearly the sensory rings of the somites in that region, and so aid in the determination of the external limits of the somites. The eye is clearly derived from one of the segmental organs of somite III. (ring 2), as the position of its nerve indicates. This view is confirmed by a comparison with the conditions existing in G. heteroclita and G. elegans.

3. Glossiphonia elongata sp. nov.

Plate 6.

a. Habitat, Form, Size, Color.

This leech first came to my notice in September, 1898. While collecting G. stagnalis from Spy Pond, near Cambridge, I found three or four leeches which, although of about the same size as stagnalis and occurring in similar situations, at once attracted my attention because of their more slender bodies and the peculiarities of their movements. These animals were carefully preserved, and diligent search was made the following spring for more. This search, however, was fruitless; but in September, 1899, I was fortunate enough to find quite a number of individuals in a pool near Fresh Pond, Cambridge, some of which I have since kept alive in aquaria for several months.

The body is less flattened dorso-ventrally in this species than in any other Glossiphonia known to me, being sub-cylindrical in cross-section. It is extremely slender, even when contracted, and both head and acetabulum are small (Figure 27, Plate 6). This species does not roll itself into a ball, as other species do, when disturbed. Instead, it writhes about or twists itself into knots like an earthworm. In aquaria it moves little from place to place, but, attached by its weak posterior sucker, extends its snake-like body searching hither and thither as for a place of concealment, or, losing its attachment, seems unable to regain it and writhes helplessly like an earthworm on a smooth surface.

The largest individuals which I have examined measure as follows: —

Length, fully extended, 25 mm.; partially contracted (as in Figure 27), about 10 mm.

Width, fully extended, less than 1 mm.; partially contracted (as in Figure 27), about 1.5 mm.

Color. — The anterior and marginal parts of the body are very clear and transparent. The rest of the body is usually of a pale yellowish-white color when the animals are first collected, but changes to a rusty yellow or pale orange color if they are kept in well-lighted aquaria for a few days. The color is due to the presence in the deeper parts of the body of rounded reserve-food cells, similar to those described as occurring in G. stagnalis. Apparently the nature of the granules in the reserve-food cells changes under the influence of daylight, so that by reflected light they appear pale orange instead of yellowish-white, the color which they have when first collected.

Superficial pigment cells of the branched type, described as occurring in G. stagnalis and other species, appear to be entirely wanting in G. elongata.

Fat cells occur in abundance in the deeper parts of the body, the contained oil drops being perfectly clear and transparent, as in G. stagnalis and G. fusca.

b. Rings, Somites, Eyes, Suckers.

The *skin* is very smooth and entirely free from papillæ.

External rings, broad and smooth, usually indistinct in the head region (somites I.–IV., Figure 23). Number of rings, 62 between oral sucker and anus (somites V.–XXVII.).

Notwithstanding the indistinctness of the rings in the head region, favorable preparations, like that represented in Figure *B*, show that the composition of somites I.–IV. is practically the same in this species as in G. heteroclita (Plate **5**) and G. fusca (Plate **4**). Somites I. and II. are uniannulate; somites III. and IV. biannulate, the anterior rings being broader and corresponding to rings 1 and 2 of a typical somite taken together.

Somite V. is likewise biannulate in this species, just as in G. stagnalis (Figure *B*; compare Plate **1**, Figure 3); in all the other species with which this paper deals, somite V. is triannulate.

Somites VI.–XXIV. (Figure 27) are triannulate, as in all other known species of this genus. Somites XXV.–XXVII. are reduced each to a single ring, a condition found in the other species described only in the case of somite XXVII., somite XXV. being always biannulate, and somite XXVI. usually so.

Eyes, two, situated about as in G. stagnalis, just posterior to the mouth, between somites III. and IV. (Figure 23). The eyes are separated from each other by a considerable space, as in G. stagnalis (Plate **2**, Figure 4) and G. fusca (Plate **4**, Figure 16). The pigment associated with them is usually small in amount; often it is wanting altogether.

The *oral sucker*, as in the other species described, lies within the limits of somites I.–IV. The *mouth* lies about in its centre (Figure 23, Plate **6**; Figure *B*). The *posterior sucker* (*act.*, Figures 24, 27) is extremely small and weak. In position it may be described as terminal rather than ventral (the position which it occupies in other species).

c. Reproductive Organs.

The *genital pores* have the same position as in G. stagnalis and G. fusca; the male (*po.* ♂, Figure 27), between the first and second rings of somite XII., the female (*po.* ♀, Figure 27), between the second and third rings of the same somite.

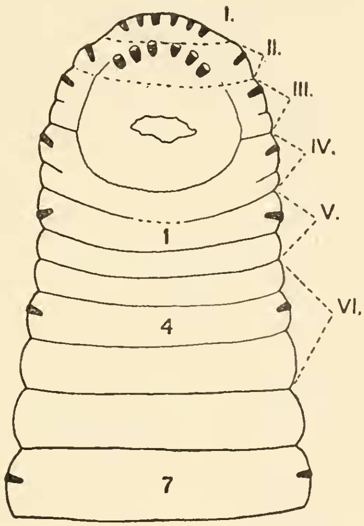

Figure *B.* — *G. elongata.* Ventral view of head end, showing annulation of head somites and position of marginal sensillæ.

Testes (*te.*, Figure 27), six pairs placed intersegmentally in somites $\frac{\text{XIII.}}{\text{XIV.}} - \frac{\text{XVIII.}}{\text{XIX.}}$, as regularly in the genus.

The *ovaries* (*oa.*, Figure 27) have the typical structure and position which they possess in other species (see p. 25). The eggs and egg-laying of this species I have not observed.

d. Digestive Tract.

The *mouth* (*or.*, Figure 23, Figure *B*) opens about in the middle of the oral sucker. The *proboscis* (*pr'b.*, Figure 27) commonly extends over about four somites (VIII.–XI.). The *salivary glands* (*gl. sal.*) are found chiefly in somite XII., though a few may lie in the adjacent somites, XI. and XIII. About thirty good-sized gland cells are found in either half of the body. In size, number, and position the salivary glands of this species resemble those of G.

stagnalis more closely than those of any other species (compare Figures 1 and 27).

The *crop* (*i'glv.*, Figure 27), as in G. stagnalis, bears a single pair of diverticula, which arise in the middle of somite XIX.; but the diverticula are shorter in this species than in stagnalis, ending usually in somite XX. (compare Figures 1 and 27). The *stomach* (*ga.*), as in all species of Glossiphonia, bears four pairs of lateral diverticula. They arise within the three somites XX.–XXII. All are directed slightly forward. The *intestine* (*in.*) is a simple tube not constricted into distinct chambers proximally as in most species. The *anus* (*an.*, Figure 24) lies just behind somite XXVII.

In the structure of its digestive tract, as well as in the composition of its somites, this species shows a more reduced, simpler condition than is found in any other species known to me, stagnalis coming nearest to it in these particulars.

e. Nervous System.

On account of the transparency of the body the central nervous system can be studied with ease in this species, either in the living animal or in whole preparations. In the ventral ganglionic chain there are, as in all species of Glossiphonia, twenty-one distinct ganglia. These innervate somites VII.–XXVII. respectively.

The brain (*cb.*, Figures 23, 27; also Figures 25, 26) represents the fused ganglia of the first six somites. The arrangement of its ganglionic capsules is the same as in G. stagnalis and G. fusca (Figures 8, 10, 12, 18). The two ventral capsules of somite VI. (*6, 6*, Figure 25) are arranged tandem, those of somites I.–V., side by side. The supra-œsophageal commissure lies well back, about over the lateral capsules of somite V. (Figure 26).

4. Glossiphonia heteroclita Linnæus (1761).

Plate 5; Plate 8, Figs. 35, 36, 38.

Hirudo heteroclita Linnæus (**1761**); H. hyalina O. F. Müller (**1774**); Clepsine hyalina Moquin-Tandon ('**26**).

a. Habitat, Form, Size, Color.

This small and transparent leech is found both in Europe and in North America. Compared with G. stagnalis and G. fusca, it has a proportionally shorter and broader body (Plate **5**, Figures 19, 22; Plate **8**, Figure 38. Compare Plate **1**, Figure 1; Plate **2**, Figure 4); in its movements, it is less active. It is found in ponds and sluggish streams, such as G. stagnalis frequents.

Length of largest individuals, when extended, 13 mm.; at rest, 8–9.5 mm.

Width, extended, 3 mm.; at rest, 4.25 mm.

Color. — The body is in general very clear and transparent, like that of a jelly-fish, but shows great individual variation in the matter of pigmentation.

First, it always has more or less of a golden-yellow tint caused by the presence, in the deeper parts of the body, of large, rounded cells each containing a single yellow oil-drop, which is blackened when treated with osmic acid.[1]

Secondly, there are usually present (but this is the variable element in the pigmentation) irregularly rounded, oval, or even somewhat branched cells, which contain pigment granules either orange, dark-brown, or black in color. These cells are found near the dorsal surface of the animal, and often produce a conspicuous color pattern by their abundance in certain regions (Figure 38, Plate 8). In their finer structure, cells of this variety are rather closely related to the deep-seated pigment cells (reserve-food cells) found in G. stagnalis and G. fusca; but in respect to position (close to the surface), and occasionally in form (irregular or branched), they approach more nearly the superficial pigment cells ("excretophores," Graf) of the species named.

The pigmented areas which are often produced in G. heteroclita by the superficial pigment cells just described are (Figure 38, Plate 8), first, a median dorsal, longitudinal band, which, when best developed, extends, with occasional interruptions, from about the seventh somite back to the anus. In the anterior ring of each somite it often broadens out into a trapezoidal form. Secondly, in about the same regions of the body (seventh to twenty-seventh somites), the anterior ring of each somite may be marked by a transverse, pigmented line, most conspicuous a short distance from the margin of the body, from which point it extends inward toward the trapezoidal, broad part of the median vitta, but rarely joins it.

Apáthy ('88) has recognized as a distinct variety (striata) animals which have the transverse markings just described. It must be said, however, that one can find in a lot of animals collected from the same locality all gradations between forms with no pigment at all (of the superficial sort) and those having a median vitta and well-defined transverse striations.

b. Rings, Somites, Eyes, Suckers, etc.

The *surface* of the body is rather smooth, being only slightly rougher than that of G. stagnalis.

External rings, rather inconspicuous, particularly in the head region, where it is often difficult to determine their number and limits accurately.

Number of preanal rings, seventy, counting as a single ring each of the somites I., II., XXVI., and XXVII., Figure 19. This number may be increased, if one counts subdivisions occasionally visible in some of the rings at the ends of the body.

Somites I. and II., as just indicated, are commonly uniannulate (Figures 35, 36, Plate 8); but somite II. is sometimes subdivided by a transverse furrow (as shown in Figure 20, Plate 5).

[1] Fat cells are also found in the deep parts of the body of G. stagnalis, G. fusca, and G. elongata, but the contained oil-drops are in those species perfectly clear and transparent, so that they do not have the effect of pigment cells, as do the fat cells of G. heteroclita.

Somite III., within the anterior part of which lies the mouth (*or.*, Figure 20), is ordinarily biannulate, as are also somites IV. and XXV. (Figures 19, 35, 36). But in the section shown in Figure 20, ring 3, the anterior annulus of somite III., appears conspicuously subdivided, a rather unusual condition. On account of the obliquity of the section, the first three somites appear in that figure a little too long in proportion to their vertical dimensions. The sensilla shown in the anterior portion of ring 3 in Figure 20 is probably not one of the segmental sense-organs, for it is found on the wrong half of ring 3.

Somites V.–XXIV. are triannulate, as in G. fusca.

Somites XXVI. and XXVII. (reckoned as uniannulate) usually appear divided at the margin only into a broader anterior and a narrower posterior part.

Compared with the species already described, the somite composition of G. heteroclita is about the same as that of G. fusca, somite abbreviation being less extensive in these species than in stagnalis and elongata.

Eyes, usually six, the anterior pair small and generally, though not always, close together in ring 5 (Figures 35, 36, Plate **8**). Sometimes this pair of eyes lies in ring 6; occasionally the pigment of one or both eyes is wanting altogether.

The second and third pairs of eyes are most often found in rings 7 and 8 respectively, but one pair or the other or both may lie a little anterior or a little posterior to the ordinary position (compare Figures 35 and 36).

The first and second pairs of eyes are directed forward and toward the side ; the third pair is directed backward and toward the side (Figures 20, Plate **5** ; Figures 35, 36, Plate **8**). The eyes in this species seem to belong to somites III., IV., and V., respectively (Figure 20); but it is possible (though I think hardly probable) that a more careful study of the nerve connections would show that in this species, as in G. elegans (Figure 29, Plate **7**), they have been derived from the sensillæ of somites II.–IV. If so, the eyes have undergone a farther displacement backward in this species than in the case of G. elegans (compare Figures 20 and 29).

Oral sucker, formed by somites I.–IV. (Figure 20).

Mouth (*or.*, Figure 20), in the anterior part of somite III., usually a little anterior to the first pair of eyes.

Posterior sucker, as in other species, slightly longer than broad (Figure 19).

c. Reproductive Organs.

Male and female genital ducts open between the first and second rings of somite XII. (rings 28 and 29, Figure 19) by a common pore, a condition peculiar, I believe, to this species.

Blanchard (**'94**) is certainly in error in describing the position of the genital pores as follows : "Porus genitalis masculus inter annulos 25–26, vulva inter annulos 27–28 hians."

Testes (*te.*, Figure 19), six pairs placed intersegmentally in somites $\frac{\text{XIII.}}{\text{XIV.}}-\frac{\text{XVIII.}}{\text{XIX.}}$. The terminal part of the vas deferens (ejaculatory part) is unusually stout and thick in this species and runs forward to the middle ring of somite XI. before turning sharply backward toward the genital pore (compare Figure 19 with Figures 4, 13, 27, and 28).

The *eggs*, which in the vicinity of Cambridge are laid in May or June (at about the time G. fusca is laying), are whitish in color and are attached *singly*, not in groups as in the other species described, to the under side of the body (Figure 22). The eggs are of about the same size as those of G. stagnalis. The number laid varies greatly with the size of the individual, the observed extremes being eleven and sixty-five. Figure 22 shows in ventral view a large individual bearing forty-five eggs, each enclosed in a separate delicate sac which serves to attach it to the under side of the body.

d. Digestive Tract.

The *mouth* has the position most common in the genus, in the anterior part of somite III. (Figure 20).

The *proboscis* (*pr'b.*, Figure 19) is long and the *œsophagus* correspondingly short. The former ordinarily extends over somites IX.–XII. and part of XIII., and the latter ends in the anterior part of somite XIV., where the crop commences.

The *salivary glands* (*gl. sal.*, Figure 19) are large and distributed often through as many as seven or eight somites, usually somites XI.–XVII.

The *crop* (*i'glr.*, Figure 19) bears six pairs of strongly developed lateral diverticula, a pair arising in the middle of each of the somites XIV.–XIX. Some or all of the first five pairs may be bilobed distally, and each of the sixth pair, which are very long, and extend back into somite XXIII., bears about five secondary, lateral diverticula, which come off metamerically in somites XIX.–XXIII.

The *stomach* (*ga.*, Figure 19), with its four pairs of lateral diverticula, lies within somites XIX.–XXII.

The *intestine* (*in.*, Figure 19) begins about in somite XXII. and extends back to the anus just behind somite XXVII. Proximally it consists of one or two chambers limited by valve-like constrictions. Posterior to this it gradually narrows backward.

e. Nervous System.

The brain (*cb.*, Figure 19) lies about in the eighth somite. The arrangement of its ganglionic capsules is peculiar in one respect. The ventral capsules of the last brain neuromere (Figure 21) lie side by side, not tandem as in the other species described in this paper. In other respects the arrangement of capsules is the same as that found in G. stagnalis and G. fusca (Figures 8, 12, 16, 18). In the individual whose brain is represented in Figure 21, the most ventral and posterior capsule of neuromere I. had a horn-like process extending back laterally into contact with the lateral capsules of neuromere III.; this condition, however, appears to be unusual.

5. Glossiphonia elegans Verrill (1872).

Plate 7; Plate 2, Fig. 5; Plate 3, Fig. 11.

Clepsine elegans Verrill ('72); (?) C. pallida Verrill ('72); C. patelliformis Nicholson ('73).

a. Habitat, Size, Color.

This species is very closely related to the European G. complanata L. and G. concolor Apáthy. Blanchard ('94), indeed, considers it identical with G. complanata L. and regards G. concolor Apáthy as merely a variety of the same species. However, both Apáthy ('88) and Oka ('94) testify to the perfect distinctness of G. complanata and G. concolor, which occur together in Europe. I have myself compared animals of the species to be described with alcoholic specimens of G. complanata from Zürich, Switzerland, and find certain small but constant differences between the two. I shall therefore describe the animals which I find here in the vicinity of Cambridge under the name proposed by Verrill in 1872, recognizing, however, that they are very closely related to the two European species (or varieties) named.

G. elegans (Plate 7) is found in localities similar to those frequented by G. stagnalis, often in company with that species. It is considerably larger, being much broader and thicker in proportion to its length, though scarcely longer.

In its movements it is more sluggish, resembling closely the small G. heteroclita in that regard. It adheres to the side of the aquarium with a tenacity displayed by no other of our species except G. parasitica.

The form of the body at rest is elliptical.

The largest individuals which I have collected measure, when alive, as follows: —

Length, fully extended, 28 mm.; at rest, 14–18 mm.

Width, fully extended, 5 mm.; at rest, about 7 mm.

Color. — Small individuals are usually of a bright, transparent green color. Adult animals, viewed with the naked eye or through a hand lens, appear of a reddish or greenish brown color, and are darker above than below.

The head is colorless. The dorsal surface of the body is marked with numerous small circular white spots, about the width of a body-ring in diameter. These spots are so placed as to form transverse and longitudinal rows, just as do the similar spots of G. fusca. The transverse rows fall on the sensory (middle) rings of their respective somites, each row containing seven spots, when the full number is present. Each of these seven spots falls in a different longitudinal row, there being three pairs of rows arranged symmetrically with reference to an unpaired (median) row, exactly as in G. fusca. The paired rows may be designated respectively *paramedian*, *intermediate*, and *marginal*, for they occupy practically the same position on the body as do the rows of white spots in the case of G. fusca, and the rows of papillæ in that of G. parasitica (Figure 6).

In addition to the spots which fall into rows as just described, a few spots are usually found scattered more or less irregularly over the surface of the body.

Two interrupted brown lines (Figure 30) appear in a paramedian position on the dorsal surface, the interruptions being due to the segmentally arranged white spots of the paramedian rows. A pair of similar, though fainter, dark lines is found on the ventral surface; but they are farther apart, including between them about the middle third of the ventral surface. The dorsal paramedian lines include between them (in the middle of the body) about one fourth of the width of the dorsal surface, which part is usually rather more heavily pigmented than the more lateral portions.

A median, clear, unpigmented band extends the entire length of the body on the ventral surface. The median row of light spots on the dorsal surface often run together in the posterior third of the body, forming a continuous light vitta.

Examining more minutely into the coloration of the animal, one finds that it is due to the same two classes of cells as produce the coloration of most other species: first, pigment cells proper, — "excretophores," Graf; and secondly, reserve-food cells.

The pigment cells proper, as in other species, occupy a superficial position in, or immediately underneath, the epidermis. They are stellate or richly branched, and are more abundant on the dorsal than on the ventral surface; in small individuals they are almost entirely wanting. The pigment in immature animals is a rust-colored or dull reddish-brown, but in full-sized animals it is usually dark-brown.

There is no pigment anterior and lateral to the eyes, nor in the white spots already mentioned. The pigment is more abundant than elsewhere in the paramedian dark lines, indeed its abundance there *produces* those lines.

The reserve-food cells in this species, as in G. fusca, are of two forms: first, the ordinary form of large reserve-food cell distributed irregularly through the deeper parts of the body; secondly, a special form of reserve-food cell, smaller, and more superficial in position, and found only in the white spots already described.

The *ordinary reserve-food cells* are large and rounded in outline, often attaining a diameter of forty mikra or more. They contain rounded granules of a bright green color both by reflected and by transmitted light. It is this form of cell which gives to the small, immature individuals their green color, and often imparts a greenish tone to the brown-colored adults.

The *special form of reserve-food cell* agrees closely both in appearance and in distribution with the similarly designated structures of G. fusca. It is found, as already stated, only in the white spots of the dorsal surface; cells of this kind occur in a group of from two to a dozen or more each, situated in the centre of a white spot, just underneath the epidermis. By reflected light they are of a light lemon-yellow color; by transmitted light, greenish-brown.

Each of the white spots in the paired rows contains an inconspicuous, low rounded papilla (much less prominent than are the papillæ of G. complanata, so far as my observations go).

The median row of white spots is less well developed than are the paired rows; in the four or five somites immediately anterior to the anus, it is commonly replaced by a continuous, median, clear vitta, within which is seen a narrower band of the lemon-yellow reserve-food cells.

Obviously the color pattern of this species resembles very closely that of G. fusca, although in a majority of characters the animal is more closely related to G. parasitica.

b. Surface, Rings, Somites, Eyes, Suckers.

The *surface* of the body is rather rough, owing to the strong development in this species of the integumental sense-organs described by Bayer (**'98**). It does not, however, bear conspicuous papillæ, as is the case with G. parasitica and the European G. complanata. The low, rounded papillæ which are found in the paired longitudinal rows of white spots are much smaller than the similarly placed papillæ of G. complanata. In this particular G. elegans seems to agree with G. concolor (see Apáthy, **'88**, page 771).

External rings, as a rule, rounded and distinct, *less convex and not pointed as are those of G. complanata*, sixty-eight in number, distributed as follows: —

Somites I.–IV. uniannulate; but the boundary between rings 1 and 2 is often inconspicuous (compare Figures 28, 29, 30), approaching the condition found in G. stagnalis, where somites I. and II. form a single broad ring, which, however, is sometimes divided by a shallow transverse furrow (Figures 3, 7).

Somites V.–XXIV. triannulate, but the condition of somite V. is peculiar. Its anterior annulus (*5*, Plate **7**, Figures 28–31) is commonly narrow and imperfectly separated from the following (sensory) annulus (*6*). This case illustrates well the initial step in reduction (or final step in elaboration, p. 33) of the triannulate somite. It represents an intermediate stage between the biannulate and triannulate condition of somite V. seen respectively in G. stagnalis (Figure 7, Plate **3**) and G. heteroclita (Figure 20, Plate **5**).

Somite XXV. is biannulate (Figure 28), but the furrow between its two annuli is often inconspicuous. Somites XXVI. and XXVII. are commonly uniannulate, though notched at the margin of the body, which fact shows that the final step in somite reduction (or initial step in somite growth) is not yet accomplished in the case of these somites.

Eyes, six, in two parallel rows close together, in rings 3 and 4 (Figure 30). Sometimes the first pair of eyes lies partly in the posterior half of ring 2 (Figure 29). The middle pair is the largest of the three; the anterior pair, the smallest. The first two pairs are directed obliquely forward, the last pair obliquely backward; all are turned away from the median plane (Figures 29, 30). From the relation of the eyes to the nerves connected with the metameric sensillæ (Figure 29), it is plain that the three pairs of eyes have been derived from the sensillæ of somites II., III., and IV. respectively. It is further evident that the single pair of eyes found in each of the species stagnalis, fusca, and elongata corresponds with the middle (largest) pair of eyes of this species, the pair belonging to somite III.

The *oral sucker*, as in the other species described, lies within somites I.–IV. (Figures 29, 31).

c. Reproductive Organs.

Male genital pore (*po.* ♂, Figure 28), between somites XI. and XII. (rings 25 and 26), a position one ring anterior to that of the same structure in the species already described.

Female genital pore (*po.* ♀, Figure 28), between the second and third rings of somite XII. (rings 27 and 28), the usual position of this structure in the genus.

Testes (*te.*, Figure 28), ten pairs. The anterior six pairs occupy the same positions as the testes in the species already described, being placed intersegmentally in somites $\frac{\text{XIII.}}{\text{XIV.}}$–$\frac{\text{XVIII.}}{\text{XIX.}}$. The remaining four pairs occur immediately behind those already mentioned; the most anterior one, between the last crop and first stomach diverticulum, in somites $\frac{\text{XIX.}}{\text{XX.}}$; the other three between successive stomach diverticula, and like them separated by rather less than metameric intervals. No other species of Glossiphonia known to me, except the European G. complanata, has normally a greater number of testes than six pairs. In that species likewise the testes number ten pairs placed exactly as in elegans. This is one of several facts showing the very close relationship of the two species named. The last one or two pairs of testes are less constant in their occurrence than those farther forward.

Eggs are laid by G. elegans, in the vicinity of Cambridge, in April, May, or as late as June. The temperature of the water in the spring undoubtedly exercises considerable influence in determining the time of egg-laying. Individuals brought into the laboratory on March 27, 1898, laid eggs nine days later. On April 29, 1900, animals of this species bearing eggs were collected from Alewife Brook, Cambridge, though G. stagnalis, found with them, apparently had not yet laid its eggs. The eggs are dull pinkish white in color and are borne on the under side of the body in from three to six large clusters, which are rather easily detached from the body, if the animal is disturbed. Each cluster contains a considerable number of eggs, often as many as twenty or twenty-five, enclosed in a delicate sac. The sacs are not arranged symmetrically in two parallel rows, as in G. stagnalis and G. fusca, but quite irregularly, a sac being attached either in the median plane of the body or to one side of it, as the case may be.

d. Digestive Tract.

The *mouth* is situated well forward in somite III., anterior to the eyes, or at least anterior to the last two pairs of eyes (Figures 29, 31).

The *proboscis* (*pr'b.*, Figure 28) is long, extending over somites VIII.–XII. There is practically no œsophagus, as I have used the term, for the pharyngeal sac containing the proboscis extends back almost to the beginning of the crop.

The *salivary glands* are numerous, often reaching seventy-five or more in number in each half of the body. They are scattered usually through somites XI.–XVIII. In Figure 28 they are represented as relatively a little too small.

The *crop* (*i'glv.*) bears *seven* pairs of large, lateral diverticula directed backward and often lobed distally. They arise in somites XIII.–XIX., always in the middle of a somite, as in the other species described. The last pair of crop diverticula is, as usual, the largest of all; it may extend back through three or four somites, giving off secondary lateral diverticula metamerically, as shown in Figure 28. Often, however, when the crop is empty, the last pair of diverticula is little longer than the preceding pair.

The *stomach* (*ga.*, Figure 28) bears, as in other species, four pairs of diverticula, which arise within the three somites XIX.–XXI. The *intestine* (*in.*) extends through the six remaining somites, consisting proximally of two distinct chambers limited by valve-like constrictions and usually situated in somites XXII. and XXIII. Distally it is a gradually narrowing tube terminating at the anus just behind somite XXVII.

e. Nephropores, Nervous System.

The *nephropores* open ventro-laterally, a little anterior to the middle of the sensory ring of a somite. The number of nephridia has not been determined for this species.

The *brain* (*cb.*, Figures 28, 30) lies for the most part in somite VII. The arrangement of its ganglionic capsules (Figure 5, Plate **2**; Figure 11, Plate **3**) is usually similar to that found in the brain of G. stagnalis and G. fusca, but the capsules are not so closely crowded together, and the supra-œsophageal commissure lies well forward, not being carried back over the middle of the brain as in G. stagnalis (Figure 12). The less crowded condition of the capsules in this species (Figure 5) explains an abnormality in their arrangement observed in the brain of a single individual out of several examined; the two ventral capsules of somite III. (usually found side by side as in G. stagnalis and the other species already described) were in this case arranged tandem, just as in ganglia in unabbreviated somites.

Comparing the conditions of the brain capsules in the several species described in this paper, one may say that the larger the leech is, the less are its capsules crowded. This fact seems to indicate that the capsules, and probably the individual ganglion cells also, do not increase in size proportionally with the growth of the leech. This is certainly true of the development of the individual, if not also of the race. for in the very young leech the ganglia of the nerve chain occur in close succession with scarcely any intervening space, whereas in the adult they may be separated by a distance of two rings or even more.

6. Glossiphonia parasitica Say (1824).

Plate 1, Figs. 2, 3*a*, 3*b*; Plate 2, Fig. 6; Plate 8, Figs. 32, 33, 37.

Hirudo parasitica Say ('**24**); Clepsine parasitica Diesing ('**50**); C. plana Whitman ('**91**[a]); ? C. chelydræ Whitman ('**91**[a]).

a. Habitat, Form, Size.

This large and conspicuously colored leech is the commonest and most widely distributed of our North American species of Glossiphonia. It is often found adhering to the bodies of turtles, whose blood it sucks, or underneath stones in pools and streams frequented by turtles. It is referable to the genus Placobdella Blanchard ('**94**), if one recognizes the validity of that genus. In it are included probably several forms which because of their close relationship I choose to call varieties. One of these has been carefully described by Whitman ('**91**[a]) under the name "Clepsine plana." In what follows I hope to supplement that description and add the description of another form which is commonly found associated with it. The two varieties agree completely, so far as I can determine, in form, size, and constitution of somites, but can be distinguished in my collections by constant differences in roughness of surface and in color pattern.

In *general form* the body in this species is very broad and flat. Whitman describes it correctly in the case of large individuals as "ovate-elliptical in contraction, emarginate posteriorly." In the case of small individuals, however, or of large individuals well extended, the emarginate condition is not present (Figure 6, Plate **2**; Figure 37, Plate **8**; Figure *C*, p. 56). The dimensions given by Whitman for the largest individuals, I can substantiate: "*Length at rest*, 5–6 cm.; width, 2.6 cm." I have an alcoholic specimen (var. rugosa) from Lake Chautauqua, N.Y., which measures 5.6 cm. in length, and 3 cm. in width. Another (var. plana) taken from a turtle brought from the Illinois River measures 5.5 cm. in length, 2.3 cm. in width. A living specimen (var. plana) taken from a snapping turtle (Chelydra serpentina) captured near Cambridge, Mass., measures at rest 5.8 cm. in length, 2.1 cm. in width. Whitman says further: "*Length in extension*, 8.5 cm.; width, 1.8 cm." My living Cambridge specimen attains in extension a length of about 7.5 cm., in which condition its greatest width is 1.5 to 1.7 cm.

b. Rings and Somites.

The *rings* are distinct except at either end of the body. The furrow between the anterior and middle rings of each somite is, however, less deep than that which separates other rings, for which reason the anterior two thirds of a somite sometimes appears like a single broad annulus, especially at the margin of the body (Figures 2, 3 *b*, Plate **1**; Figure 6, Plate **2**; Figures 32, 33, 37, Plate **8**).

Somites I., II., and XXV.–XXVII. uniannulate (Figures 6, 33, 37), but XXV. and

XXVI. are commonly divided at the margin of the body into a broad anterior and a narrow posterior portion. Somites III. and IV. are biannulate, the broad anterior ring in each case bearing the sensillæ and representing both the anterior and the middle ring of a triannulate somite (Figure 2, III.–VI.). The remaining preanal somites (V.–XXIV., Figure 6) are triannulate, but the posterior annulus of XXIV. is narrower than the adjacent annuli (Figure 6), and the anterior and middle annuli of somite V. are united ventrally while separated by only a very shallow furrow dorsally (*7*, *8*, Figures 2, 3 *b*, Plate **1**. These two cases illustrate the centripetal progress of abbreviation (or arrested development), that part of each terminal triannulate somite being affected which is adjacent to an abbreviated somite.

In Figure 32, Plate **8**, is shown a rather unusual condition, the apparent disappearance of the furrow separating somites II. and III.[1]

The total number of *preanal rings* is sixty-nine, counting somites I., II., and XXV.–XXVII. as uniannulate, III. and IV. as biannulate, and V.–XXIV. as triannulate (Figure 6).

c. Eyes, Mouth, Oral Sucker.

The *eyes* appear in the living animal, or in whole preparations, as a single pair closely united and situated in rings 3 and 4 (somite III.). See Figure 6, Plate **1**; and Figures 32, 33, Plate **8**. An examination of sections, however, particularly of young individuals, shows that there are really three distinct pairs of eyes present, there being a small rudimentary pair anterior, and another still more rudimentary posterior to the principal pair of eyes, exactly as shown for "C. hollensis" by Whitman ('**92**, Figure 6).

All three pairs of eyes[2] are partially imbedded in a common pigment mass, the anterior and middle pairs being directed forward, the posterior pair backward, just as in G. elegans and G. heteroclita (Figures 20, 29). The largest

[1] A similar condition is figured by Whitman ('**91**[a]) in his Plate 15, Figure 1. In his text, however, Whitman says (p. 412): "In front of the eyes I was unable to discover any distinct rings. In another species *C. chelydræ*, from Wisconsin, there are three narrow rings in front of the eyes; and the first is marked by the usual metameric sense-organs. Although no metameric sense-organs were recognized in front of the eyes in *C. plana*, the correspondence of other metameric characters in the two species is sufficiently close to enable me to identify the ocular rings as equivalents. The preocular part of the head is, therefore, probably equivalent to the first somite of *C. chelydræ*, and is so numbered in Figure 1."

In view of Whitman's subsequently published studies on "The metamerism of Clepsine" ('**92**), I think he unquestionably would now recognize *two* preocular somites both in "C. plana" and in "C. chelydræ"; at any rate, that is the number found in the species which I am describing (Figure 2, Plate **1**). Since Whitman has pointed out no other difference between his "plana" and "chelydræ" than the uncertain one of preocular rings, I consider that their specific distinctness remains to be established.

[2] Only the largest (middle) pair of eyes appear in the section shown in Figure 2.

(middle) pair is closely united with sensillæ situated in the first ring of somite III. (Figure 2), a fact which Whitman ('92) established for "C. hollensis" and which I can completely confirm for the species under discussion (Figure 2).[1]

Whitman ('92) further established the fact that the anterior pair of eyes in "hollensis" originates in connection with the sensillæ of somite II. He gives no statement as to the origin of the posterior pair. Comparison with G. elegans (Figure 29), however, leads me to regard this pair as probably derived from the sensillæ of somite IV. If so, the condition of the eyes in parasitica can be derived in its entirety from that found in G. elegans by supposing that both the anterior and the posterior pairs of eyes have become rudimentary and been brought close to the large middle pair.

The *mouth* (*or.*, Figure 2) apparently lies between somites I. and II.; in other species it lies farther back, usually in the anterior part of somite III. The *oral sucker* is formed by somites I.–IV., as in other species.

d. Reproductive Organs.

The *genital pores* are situated in this species exactly as in G. elegans; the male (*po.* ♂, Figure 3 *b*), between somites XI. and XII. (rings 27 and 28); the female (*po.* ♀), between the middle and posterior annuli of somite XII. (rings 29 and 30).

Testes, six pairs situated intersegmentally in somites $\frac{\text{XIII.}}{\text{XIV.}}-\frac{\text{XVIII.}}{\text{XIX.}}$, the usual position in the genus.

The *eggs* are large, white, and opaque. In the vicinity of Cambridge they are laid in May and June, perhaps also in July. In the case of those animals which laid in the laboratory, the eggs appeared to be attached loosely in a single group of fifty or more to the side of the aquarium, rather than to the body of the leech as is the case in the other species studied. The leech remained closely arched over the eggs, — a position from which it was removed only with great difficulty.

e. Digestive Tract.

The digestive tract resembles very closely that of G. elegans, but has one strikingly distinctive feature: the *salivary glands* (*gl. sal.*, Figure 3 *b*), instead of being distributed through several somites in the crop region, are closely aggregated into two compact groups in each half of the body, these groups lying symmetrically, a pair on either side of the proboscis, within somites IX.–XI.

[1] On account of this and other close structural agreements with "C. hollensis" as described by Whitman ('92), I was for some time inclined to regard that name as well as "chelydræ" as a synonym with parasitica, and I have so treated it in a recent publication (Castle, 1900). Professor Whitman, however, has subsequently informed me in a letter that in hollensis "there are several pairs of pigmented eyes behind the pair usually recognized as 'eyes.' These are quite conspicuous in the living leech, and I have never seen any such feature in other Clepsines." This being so, it is probable that hollensis should rank as a distinct species.

The *crop* bears *seven pairs* of lateral diverticula, as in G. elegans and the closely related European G. complanata, with both of which this species has many points in common. The first pair of diverticula arise in the anterior or middle part of somite XIII. and are two or three lobed, the anterior lobe being prolonged forward through somites XII. and XI. The five following pairs of crop diverticula arise in the middle of somites XIV.–XVIII. respectively, and are usually bilobed distally. The last (seventh) pair of crop diverticula extend far back of their origin in somite XIX., often into somite XXIII. They give off secondary lateral diverticula, a pair in each of the somites through which they extend.

The crop diverticula are often a conspicuous feature of this species when viewed in a living condition from the ventral side of the animal, for numerous large green chromatophores aggregate about the crop and show through the clear ventral body wall the form of the crop outlined in green.

f. Nephropores, Nervous System.

The *nephropores* (*nph'po.*, Figure 3 *b*) open ventrally, anterior to the middle of the sensory ring of a somite, as stated by Whitman ('**91**[a]). They are present in the eighth and all the following triannulate somites.

I have nothing new to add to Whitman's ('**92**) excellent account of the *central nervous system.* It is important to notice, however, the arrangement of the ventral capsules in the brain region (Figure 3 *b*). Those of neuromeres III.–VI. *all lie in a single row* in the median plane; that is, have what I have called the tandem arrangement. The ventral capsules of neuromere II. (*2*, *2*, Figure 3 *b*) have the side-by-side position found in all the species examined by me.

Figure 3 *a* is a dorsal view of the brain and shows that the supra-œsophageal commissure in the species lies far forward in what may well be regarded as its primitive position.

The less crowded condition of the brain capsules in this as compared with other species is interesting, as showing that the smaller the leech is, the more crowded are its brain capsules likely to be (compare page 50).

g. Papillæ, Coloration.

I have reserved to the last, in describing this species, the discussion of papillæ and coloration, for it is on the basis of these characters alone that I am able to distinguish two varieties, plana and rugosa, which I find associated together, but apparently without intergrading forms, in collections from Cambridge, Mass., Lake Chautauqua, N. Y., Lake Forest, Ill., and Wellsville, Kan., a very wide range extending across the Mississippi valley and the Atlantic seaboard.

(1) *Var. plana Clepsine plana* Whitman, '**91**[a]).

This variety has a relatively smooth skin, which bears dorsally small dome-shaped *papillæ*, the most conspicuous of which are placed as indicated by stars in Figure 6, Plate 2. They include five longitudinal rows of papillæ found on the middle (sensory) annuli of usually all the triannulate somites. These rows may be designated, from their position, median, marginal, and intermediate, the first named being unpaired, the other two paired.

A row of papillæ is found also between the median and each intermediate row, but these papillæ are situated not on the middle, but on the *posterior* annulus of each of the somites from about VIII. to XXII. inclusive (Figure 6). These will be designated paramedian rows.

The most conspicuous papillæ of somites XXV.–XXVII. are usually placed as indicated in Figure 6. They consist, first, of a continuation of the marginal rows back to the anus; secondly, of two rows of three papillæ each, placed one on either side of the median plane and too near it to fall in the paramedian rows found farther forward.

Other less conspicuous papillæ occur on the dorsal surface of the body and posterior sucker, but no papillæ are found on the ventral surface of the animal.

The general *color* of the body above is brown variegated with yellow, orange, and green. Light areas of yellow or pale orange form : —

I. A median vitta extending from the anterior end of the body back to somite XXV., usually without interruption, but not always so, and expanding commonly at six places, namely, (1) in somites VI. and VII. (Figure 32, Plate 8) ; (2) in somite IX.; (3) in somites XII. and XIII. ; (4) in somites XV. and XVI. ; and (6) in somite XXII. (and the posterior part of somite XXI.). The median row of papillæ already described falls entirely in the median light vitta. In somites XXV.–XXVII. both vitta and papillæ become double, dark pigment being found along the median line back to the anus, usually behind it also quite to the posterior margin of the acetabulum. The double (or paramedian) light vitta of somites XXV.–XXVII. contains the three pairs of papillæ shown in Figure 6, Plate 2 ; it may or may not be continuous with the median light vitta farther forward.

II. Throughout the greater part of the body the papillæ of the intermediate rows lie each in an irregularly rounded light spot. The successive spots of each half of the body may become confluent so as to form an irregular, frequently interrupted, longitudinal band.

III. The margins of the body are conspicuously marked with metameric light spots from about the third or fourth somite back to somite XXV. Some idea of the form and position of these spots may be obtained from an examination of the stippled areas in Figure 6, Plate 2, and Figure 32, Plate 8. Each spot is typically V- or U-shaped and is placed on the adjacent non-sensory rings of two successive somites. The usually hollow centre of the V or U is formed by a spot of brown sometimes bordered with orange. The margin of the sensory ring is generally darker in color than its more median parts, so that it is strongly in contrast with the metameric light spots which it separates.

The posterior sucker is decorated with radially placed triangular light spots (Figure 6) resembling the marginal spots of the body. Other irregularly rounded light spots may be found on the dorsal surface of the body in light-colored individuals, usually associated with certain papillæ.

There is a certain correlation in the development of light spots in different parts of the body; an animal which has a well-developed median vitta will also have conspicuous marginal and intermediate light spots and vice versa.

The ventral side of the body is much lighter in color, marked only by a few longitudinal bands of dull brown or greenish brown. The number of these bands is either eleven or twelve according as there is present, in addition to five pairs of bands laterally placed, a single broad median band or a pair of narrow paramedian bands separated by an irregular median clear band.

From the under side of the body one can often see in living animals the green pigmented crop diverticula showing through the semi-transparent body.

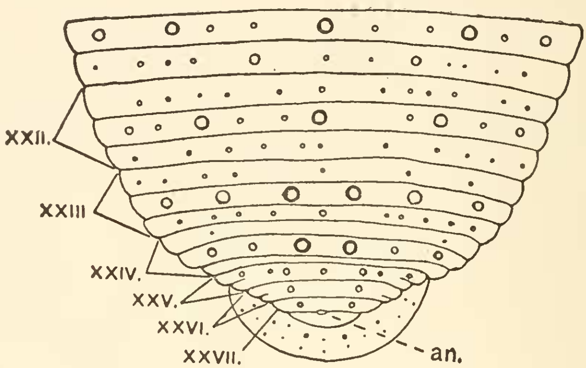

FIGURE *C.* — *G. parasitica, var. rugosa.* Dorsal view of posterior part of body, showing position and approximate relative size of papillæ. From a Cambridge, Mass., individual.

(2) *Var. rugosa, var. nov.*

The dorsal surface of the body is much rougher in this variety, the *papillæ* being larger, more numerous, and structurally more complex. Instead of being simple, low, and dome-shaped, the more conspicuous papillæ are extended distally in several divergent whitish points, giving the body a decidedly rough, harsh feeling to the touch in the case of hardened specimens. The larger papillæ are likewise rendered more conspicuous by the fact that they are commonly unpigmented, though placed in a generally dark background.

The arrangement of the principal rows of papillæ on the dorsal surface is similar to that in G. plana, but with the following easily determined and constant difference. In somites XXIII. and XXIV. (Figure *C*), the median row of papillæ becomes inconspicuous or disappears altogether, and a large papilla appears on either side of the median line, on the sensory ring of each somite. The ventral surface is free from papillæ as in plana.

The *color pattern* is somewhat similar to that of plana, but the contrasts are less striking and the colors less brilliant. The general color effect of the dorsal surface is a grayish brown. Marginal spots of light yellow are present, as in plana, on the non-sensory rings, but they are smaller and do not extend so far mesiad from the margin of the body. Practically all the larger papillæ appear as small white spots in a generally dark background.

The median vitta is not a continuous light band as in plana, but is interrupted at regular intervals by spots of a darker color than the general dorsal surface. It begins as a narrow median light band on the head and neck, constricted or sometimes interrupted in the posterior part of somite VI., less often constricted or interrupted in somite V. also. About in annulus 19, somite IX., begins a narrow dark band which continues to the middle of somite XII. Then come alternating light and dark spots, three of each. A light spot extends over four annuli, a black spot over five as follows: Light spots, annuli 29–32 (Figure 6), 38–41, 47–50; dark spots, annuli 33–37, 42–46, 51–55. Another light spot covers rings 56–64 or 65, broadening out posteriorly so as to include the paired papillæ of somites XXIII. and XXIV. (Figure *C*). This is followed by a median dark spot extending back past the anus to the margin of the posterior sucker.

The posterior sucker is marked by alternating light and dark rays, very much as in plana (Figure 6); it also bears papillæ like those of the body farther forward.

Ventrally the body is light gray in color, owing to the presence there of scattered pigment flecks, which, however, are not arranged in longitudinal bands as in plana.

V. MUTUAL RELATIONSHIPS OF THE SPECIES DESCRIBED.

The species described in this paper, with the exception of heteroclita, fall naturally into two distinct groups (Figure *D*, page 58), which may be designated respectively the stagnalis and the parasitica groups. The former includes the three species stagnalis, elongata, and fusca; the latter, parasitica and elegans, with the closely related European species, complanata and concolor. Heteroclita occupies a somewhat isolated position intermediate between these two groups.

As arranged in Figure *D*., the species form a series in which there is from left to right an increasing degree of complexity of structure. This appears from an examination of rugosity, somite structure, crop diverticula, and certain other characters.

In the species of the stagnalis group (1) there is a single pair of eyes derived from the sensillæ of somite III., (2) the genital pores are separated by a single ring, namely, the middle (sensory) ring of somite XII., and

(3) the crop diverticula are simple and never exceed six pairs in number. (4) All three species are small, (5) have relatively smooth skin, and (6) at least two of them bear the eggs in clusters attached symmetrically in a double row to the under side of the body, the condition in the third species being unknown.

In parasitica and elegans (1) there are three pairs of eyes derived respectively from the sensillæ of somites II., III., and IV., (2) the genital pores are separated by two rings, the anterior two rings of somite XII., (3) the crop diverticula number seven pairs and are lobed, (4) the integument is rough and bears papillæ, (5) the attachment of the egg

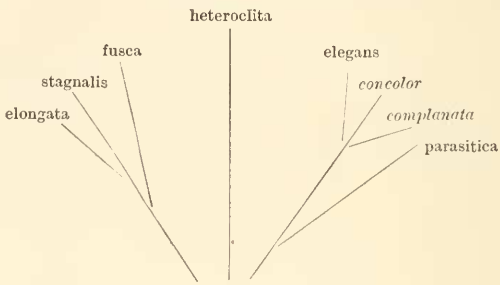

FIGURE *D.* Diagram indicating relationships of the species described.

clusters to the body, when such attachment exists, is imperfect and the arrangement of the clusters irregular.

The European species complanata and concolor are very closely related to elegans, complanata certainly, perhaps also concolor, being intermediate between it and parasitica.

In view of the many points of similarity between parasitica and complanata, there seems to me to be insufficient ground for placing them in distinct genera, as proposed by Blanchard.

Allusion has already been made to the somewhat isolated position of heteroclita. In size and in the character of its integument, it resembles the stagnalis group, likewise in the number of its crop diverticula ; in regard to the lobed condition of its crop diverticula, it resembles the parasitica group. In the number of its eyes (three pairs), it likewise resembles the latter group, but the derivation of these apparently is from different somites (III.–V. in heteroclita, II.–IV. in parasitica and elegans.) As regards the position of the genital pores and the way the eggs are borne, it differs alike from both groups.

VI. PARASITES.

Three different endo-parasites, of which I find no notice in the literature, in addition possibly to one already described by Bolsius ('96), infest more or less commonly the species of Glossiphonia found in the vicinity of Cambridge, Mass. One of these is a small nematode, another a trematode, these two having been observed in the body of G. stagnalis only; the third is a sporozoön found in at least four of the species described in this paper.

In January, 1898, I first observed a minute *nematode* parasite wriggling about in the central lacunar space of a live G. stagnalis. Another similarly parasitized leech was found upon further search, and a third was found in the following March, the ovary of the host containing at that time full-grown eggs. The parasite in the last-mentioned case lay close to the contractile dorsal blood-vessel, a very common position for it, as subsequent observations showed. In the spring of 1899 several parasitized individuals were collected and studied; and others were observed in the fall of 1899.

The length of the parasite is about the same in the case of all individuals examined; namely, 1.43 mm. In form, the worm is slender and thread-like, being widest near the middle of its body, where it measures 0.027 mm. in breadth. From there it tapers almost imperceptibly toward either end. The posterior end of the body is sharply pointed; the anterior end blunt, its centre being occupied by the very minute, conical mouth.

Examination of a large number of individuals of G. stagnalis in the spring of 1899 showed that between five and ten per cent of the individuals taken from a particular pond, in which the species abounds, contained the nematode parasite. Usually only a single parasite has been observed in the body of a host, but in one case there were three.

The nematode is generally found either coiled up (but not encysted) or wriggling about in the central lacuna (body cavity), in the middle or toward the posterior end of the body. The presence of the parasite does not seem seriously to inconvenience its host, for the parasitized individuals are as large and well developed as those free from parasites, and contain sexual products in equal abundance.

Parasitized individuals were kept in aquaria for several weeks without the occurrence of any noticeable change in the condition of the parasites. This fact and the manifest immaturity of all the parasites examined makes me believe that the leech is an intermediate host and that the nematode probably attains maturity after passing from the body of the leech into that of another host, perhaps some fish, which feeds upon the leech. How the nematode gets into the body of the leech is likewise unknown, probably from the body of some snail or other small pond animal on which the leech feeds.

The supposed *trematode* parasite I have observed but once, in November, 1899, when three individuals were observed encysted in a single G. stagnalis. Unfortunately they with their host died in captivity before I had an opportunity to study them carefully. They lay imbedded in the deeper muscle layers of their host's body, toward its anterior end, each enclosed in a delicate rounded cyst. A single ventral sucker was observed in the parasite and this seemed to lie a little nearer one end of the body. Toward the opposite end, a dark granular substance was observed in the interior of the body, probably in the digestive tube. My study of the parasite, was so incomplete that I should not feel warranted in asserting the absence of a second sucker more nearly terminal in position than the one observed. No measurements of the cysts were made, but I should estimate their diameter roughly at 0.50–0.75 mm.

About half of the individuals of G. elongata which have come under my observation contain a *gregarine* which appears to be identical with that described by Bolsius ('96) as occurring in G. complanata (Clepsine sexoculata). I have not, however, made a sufficiently careful study of it to enable me to add anything to his account. I find the parasite attached *always to the wall of the stomach diverticula* (Figure 27, *ga.*), never in crop or intestine.

A majority of the individuals of G. fusca collected by me contain *sporozoa* in an encysted condition. These parasites are quite common also in the body of G. heteroclita and that of G. elegans, and I have found them in a single individual of G. stagnalis.

Whether or not they represent another stage of the gregarine found in G. elongata, I am unable to say. As already indicated, I have observed them only in stages of encystment, more or less advanced. One finds the heavily staining sporocyst in whole preparations of its host, usually near the margin of the body, imbedded in the deeper-lying muscle layers (longitudinal and dorso-ventral). The sporocysts which I have observed were spherical in form; the largest ones examined were about 0.13 mm. in diameter and were protected by a thick, dense wall. I have not yet been able to obtain sporocysts containing fully formed spores. Data, accordingly, are wanting for a full description of this parasite, as well as of the others mentioned, and only a portion of its life history is known. Nevertheless I insert this notice in the hope that some one else may be able hereafter to make use of my fragmentary observations.

CAMBRIDGE, MASS., June, 1900.

BIBLIOGRAPHY.

Apáthy, S.
'88. Süsswasser-Hirudineen. Ein systematischer Essay. Zool. Jahrb., Abth. f. Syst., Bd. 3, pp. 725–794.

Apáthy, S.
'88[a]. Analyse der äusseren Körperform der Hirudineen. Mitth. Zool. Sta. Neapel, Bd. 8, pp. 153–232, Taf. 8, 9.

Bayer, E.
'98. Hypodermis und neue Hautsinnesorgane der Rhynchobdelliden. Zeit. f. wiss. Zool., Bd. 64, pp. 648–696, Taf. 23–25, 10 Textfig.

Blanchard, R.
'94. Hirudinées de l'Italie continentale et insulaire. Boll. Mus. Zool. ed. Anat. comp. Torino, Vol. 9, n. 192, 81 pp., 30 Fig.

Bolsius, H.
'96. Un parasite de la "Glossiphonia sexoculata." Mem. Pontif. Accad. Nuovi Lincei, Vol. XI., 5 pp., 1 Pl.

Bristol, C. L.
'99 The Metamerism of Nephelis. Jour. of Morph., Vol. 15, pp. 17-72, Pls. 4–8.

Budge, J.
'49. Clepsine bioculata Savigny. Verh. d. naturh. Vereins preuss. Rheinlande, Bd. 6, pp. 89–155, Taf. 5, 6.

Castle, W. E.
1900. The Metamerism of the Hirudinea. Proc. Amer. Acad. Arts and Sci., Vol. 35, pp. 285–303, 8 Fig.

Diesing, K. M.
'50. Systema helminthum. 8vo, 2 vol., Vindobonae.

Graf, A.
'99. Hirudineenstudien. Abhandl. Leop.-Carol. Akad. d. Naturf., Bd. 72, Nr. 2, pp. 217–404, Taf. 1–15, 26 Textfig.

Gratiolet, P.
'62. Recherches sur l'organisation du système vasculaire dans la sangsue médicinale et l'aulostome vorace. Ann. Sci. Nat., Zool., T. 17, pp. 175–225, Pl. 7.

Johnson, J. R.
'16. Observations on the Hirudo vulgaris. Phil. Trans. Roy. Soc. London, pp. 13–21, Pl. 4.

Lee, A. B.
'96. The Microtomist's Vade-mecum. Fourth edition. Philadelphia.

Linnaeus, C.
1758. Systema Naturae. 10th edition.

Moore, J. P.
'98. The Leeches of the U. S. National Museum. Proc. U. S. Nat. Mus. Vol. 21, pp. 543–563, Pl. 40.

Moore, J. P.
1900. A Description of Microbdella biannulata, with Especial Reference to the Constitution of the Leech Somite. Proc. Acad. Nat. Sci. Philadelphia, pp. 50–75, Pl. 6.

Moquin-Tandon, A.
'46. Monographie de la famille des Hirudinées. 8vo, 448 pp. Atlas, 14 Pl. Paris.

Müller, O. F.
1774. Vermium terrestrium et fluviatilium, etc. 4to. Vol. 1, Havniae et Lipsiae. (See Vol. I., "Helminthica," p. 49.)

Nicholson, H. A.
'73. Contributions to a Fauna Canadensis; being an Account of Animals dredged in Lake Ontario in 1872. Canadian Journal, Vol. 13, pp. 490–506, 4 Textfigs.

Oka, A.
'94. Beiträge zur Anatomie der Clepsine. Zeit. f. wiss. Zool., Bd. 58, pp. 79–151, Taf. 4–6.

Savigny, J. C.
'20. Système des Annélides. Folio, Paris.

Say, T.
'24. Zoölogy. Keating's Narrative of an Expedition to the Source of St. Peter's River, etc., in 1823, under S. H. Long. 2 vols. Philadelphia. Vol. 2, pp. 253–378, Pl. 14, 15.

Verrill, A. E.
'74. Synopsis of the North American Fresh-Water Leeches. Rept. U. S. Fish Commissioner for 1872–3, Pt. 2, pp. 666–689.

Whitman, C. O.
'85. The External Morphology of the Leech. Proc. Amer. Acad. Arts and Sci., Vol. 20, pp. 76–87, 1 Pl.

Whitman, C. O.
'91. Spermatophores as a Means of Hypodermic Impregnation. Jour. of Morph., Vol. 4, pp. 361–406, Pl. 14.

Whitman, C. O.
'91[a]. Description of Clepsine plana. Jour. of Morph., Vol. 4, pp. 407–418, Pl. 15.

Whitman, C. O.
'92. The Metamerism of Clepsine. Festschr. Leuckarts, pp. 385–395, Pl. 39, 40, Leipzig.

EXPLANATION OF PLATES.

All figures were drawn with the aid of Abbé's camera lucida, unless otherwise stated in the explanation of figures.

Arabic numerals in the figures designate rings, which, except in the case of Figures 23 and 27, Plate 6, are numbered from the extreme anterior end of the body backward; Roman numerals designate somites numbered in the same manner.

ABBREVIATIONS.

act.	Acetabulum (posterior sucker).	*oc.*	Eye.
an.	Anus.	*œ.*	Œsophagus.
cb.	Brain.	*or.*	Mouth.
dt. ej.	Ejaculatory duct.	*po.* ♂	Male genital pore.
ga.	Stomach.	*po.* ♀	Female genital pore.
gl. d.	Dorsal gland.	*pr'b.*	Proboscis.
gl. sal.	Salivary glands.	*sac. phy.*	Pharyngeal sac.
in.	Intestine.	*suc. or.*	Oral sucker.
i'glv.	Crop.	*te.*	Testis.
lac. marg.	Marginal lacuna.	*va. df.*	Vas deferens.
nph'po.	Nephropore.	*va. ef.*	Vas efferens.
oa.	Ovary.	*vs. sem.*	Seminal vesicle.

PLATE 1.

Fig. 1. *G. stagnalis.* Entire digestive tract shown; somite limits indicated by transverse lines, rings not represented. From an entire preparation. × about 16.

Fig. 2. *G. parasitica.* Parasagittal section of head end of a small individual taken from a turtle (probably Chelopus insculptus Le Conte) bought in a Philadelphia market. Only one (the largest) of the three closely associated pairs of eyes appear in the section.

Fig. 3. *G. stagnalis.* Ventral view of head end, showing mouth, oral sucker, and the marginal sensillæ and annulation of somites i.–vi. From an entire preparation. × 83.

Fig. 3 *a*. *G. parasitica.* Dorsal view of brain.

Fig. 3 *b*. *G. parasitica.* Ventral view of anterior part of a small individual obtained from the same source as that shown in Figure 2. From an entire preparation.

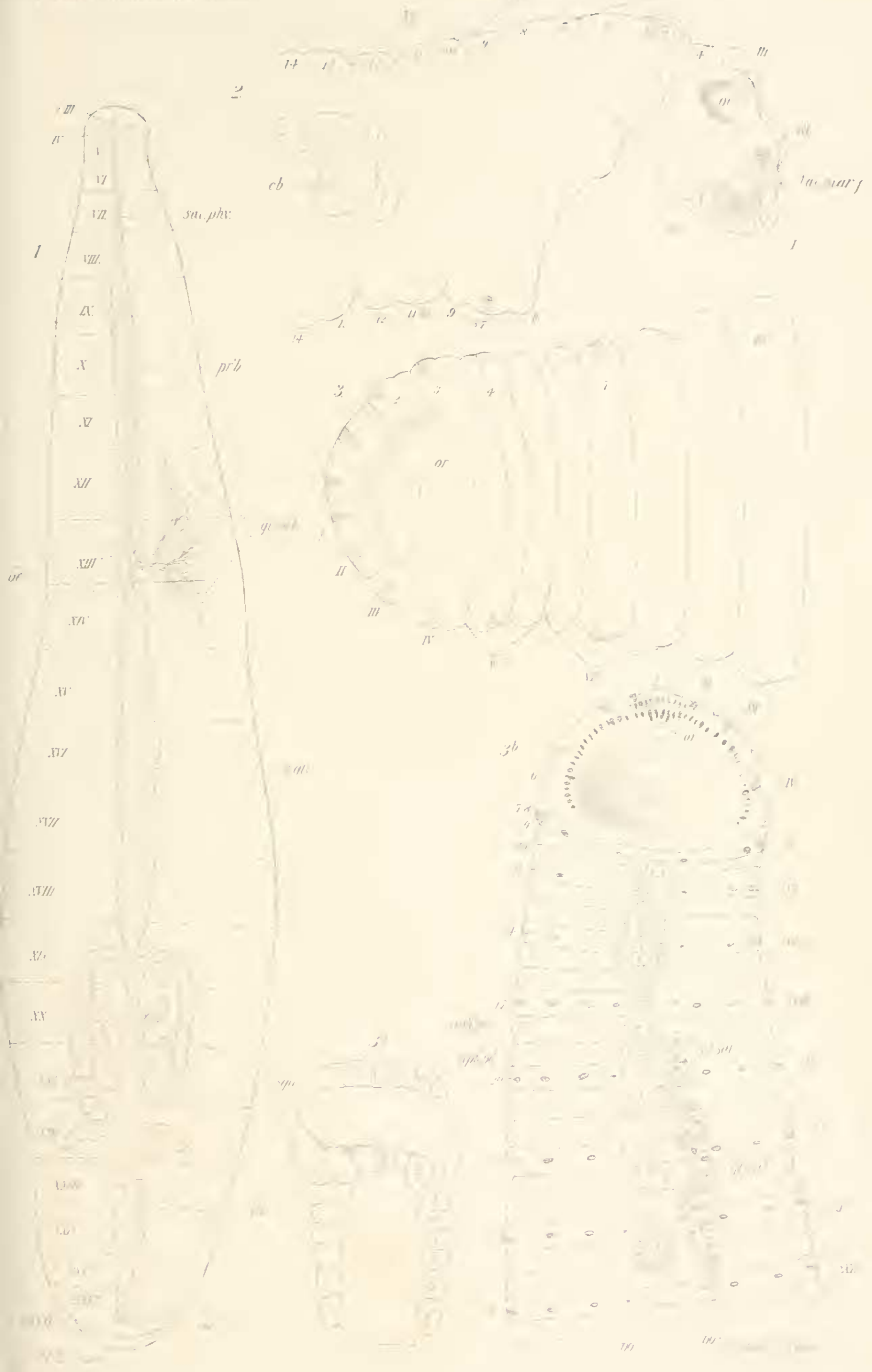
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PLATE 2.

Fig. 4. *G. stagnalis.* Diagram showing annulation, central nervous system, reproductive organs (male in left, female in right half of figure), nephropores, etc. The outline of the body was drawn from a whole preparation (× about 16); everything else is diagrammatic, representing the *average* form and position of organs as determined by examination and comparison of several individuals.

Fig. 5. Brain of *G. elegans*, ventral view. From an entire preparation. × 52.

Fig. 6. *G. parasitica.* Dorsal view of a young individual from Havana, Illinois, partially extended. × about 10. The starlike structures indicate papillæ; not all of those shown were observed in the individual figured, some being supplied from the study of larger individuals in which the papillæ are more conspicuous.

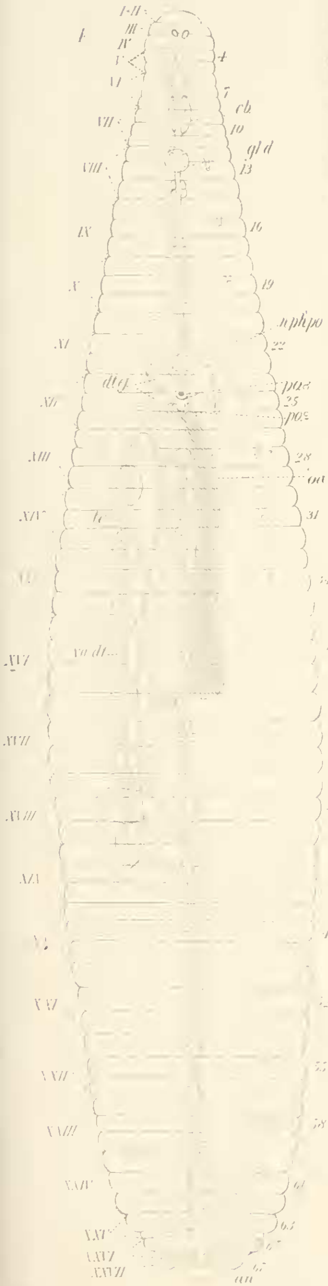
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PLATE 3.

Fig. 7. *G. stagnalis.* Parasagittal section of anterior part of body. × 96.

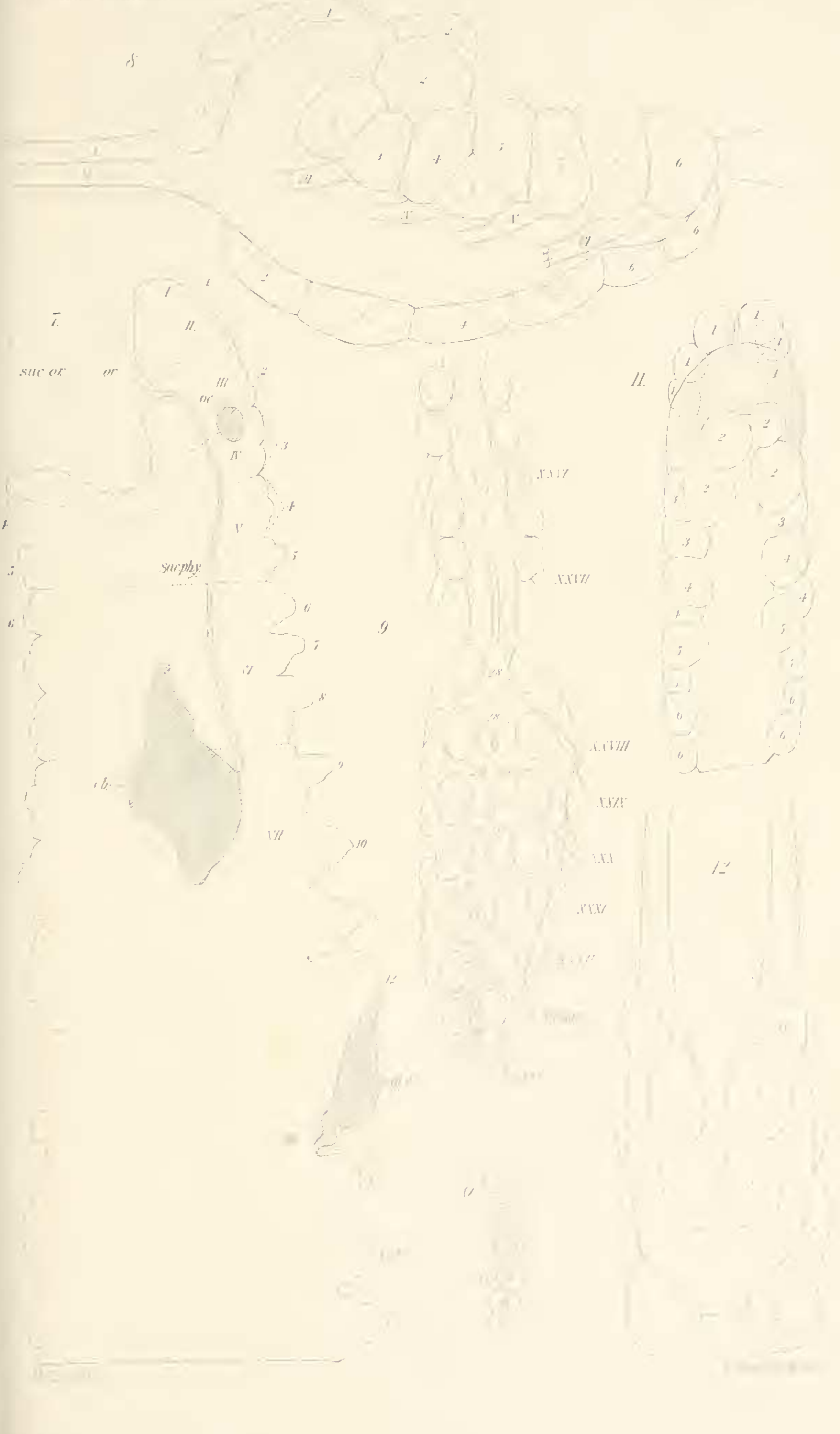
Fig. 8. *G. stagnalis.* Brain viewed from left side. Reconstructed from sections. × 208. Roman numerals designate segmental nerves; Arabic numerals, the ganglionic capsules which supply nerve fibres to same.

Fig. 9. *G. stagnalis.* Posterior part of ventral ganglionic chain, dorsal view, reconstructed from frontal sections. Arabic numerals designate ventral ganglionic capsules; Roman numerals, metameric nerve bundles. × 170.

Fig. 10. *G. stagnalis.* Diagram showing the arrangement of ganglionic capsules on the ventral surface of brain.

Fig. 11. *G. elegans.* Dorsal view of brain.

Fig. 12. *G. stagnalis.* Dorsal view of anterior part of brain. From frontal sections combined. × 167.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XXVIII

PLATE 4.

G. fusca.

Fig. 13. Dorsal view of a small individual. For clearness furrows between annuli are represented only at the margin of the body, except where they mark somite boundaries. Testes are shown only in the right half of the figure, salivary glands only in the left half. From an entire preparation. × about 34.

Fig. 14. Parasagittal section of head end. × 52.

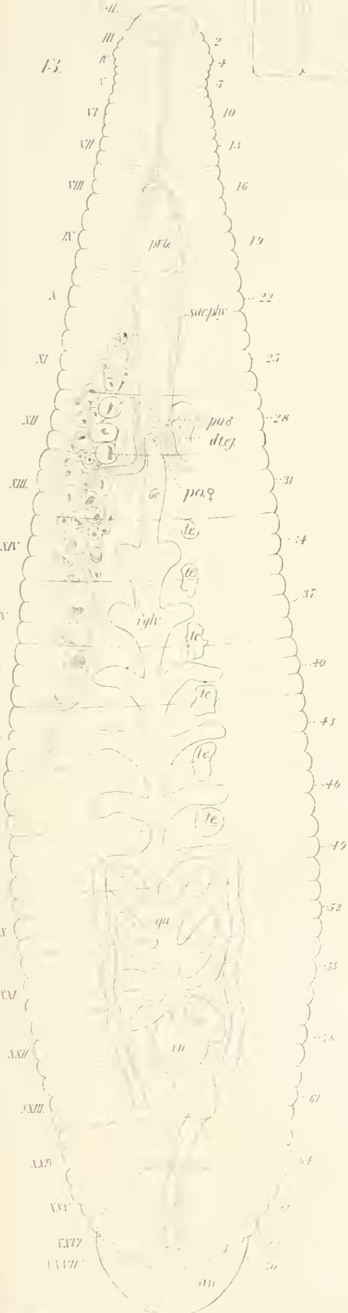
Fig. 15. Head end of young individual viewed from left side. From an entire preparation. × 83.

Fig. 16. Head end of individual shown in Figure 13. Dorsal view. × 83.

Fig. 17. Group of reserve-food cells from one of the segmental clear spots marking the sensory annuli. From a living animal. × 365.

Fig. 18. Ventral view of brain. From an entire preparation. × 208.

13.



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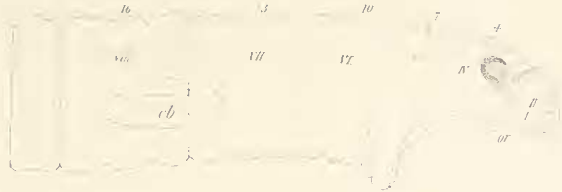

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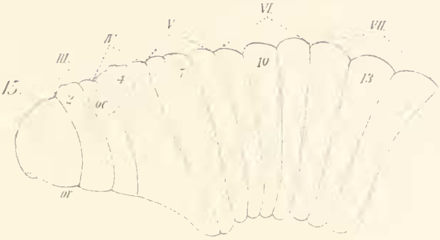

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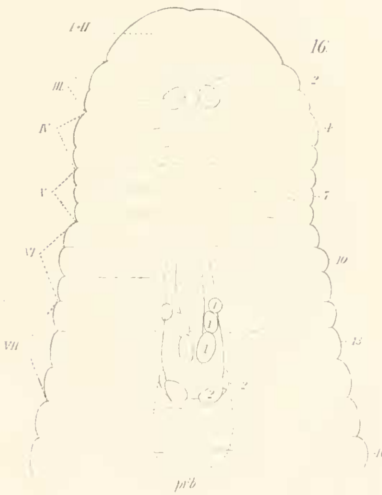


17.

18.

PLATE 5.

G. heteroclita.

Fig. 19. Dorsal view of a rather small individual. For clearness furrows between annuli are shown only at the margin of the body, except where they mark somite boundaries. Salivary glands are shown only in the right half of the figure, testes only in the left half. From an entire preparation. × 62.

Fig. 20. Combination of two or three successive parasagittal sections of head end. × 83.

Fig. 21. Brain viewed from the left side. From several sections combined.

Fig. 22. Ventral view of a living animal bearing eggs. × about 13.

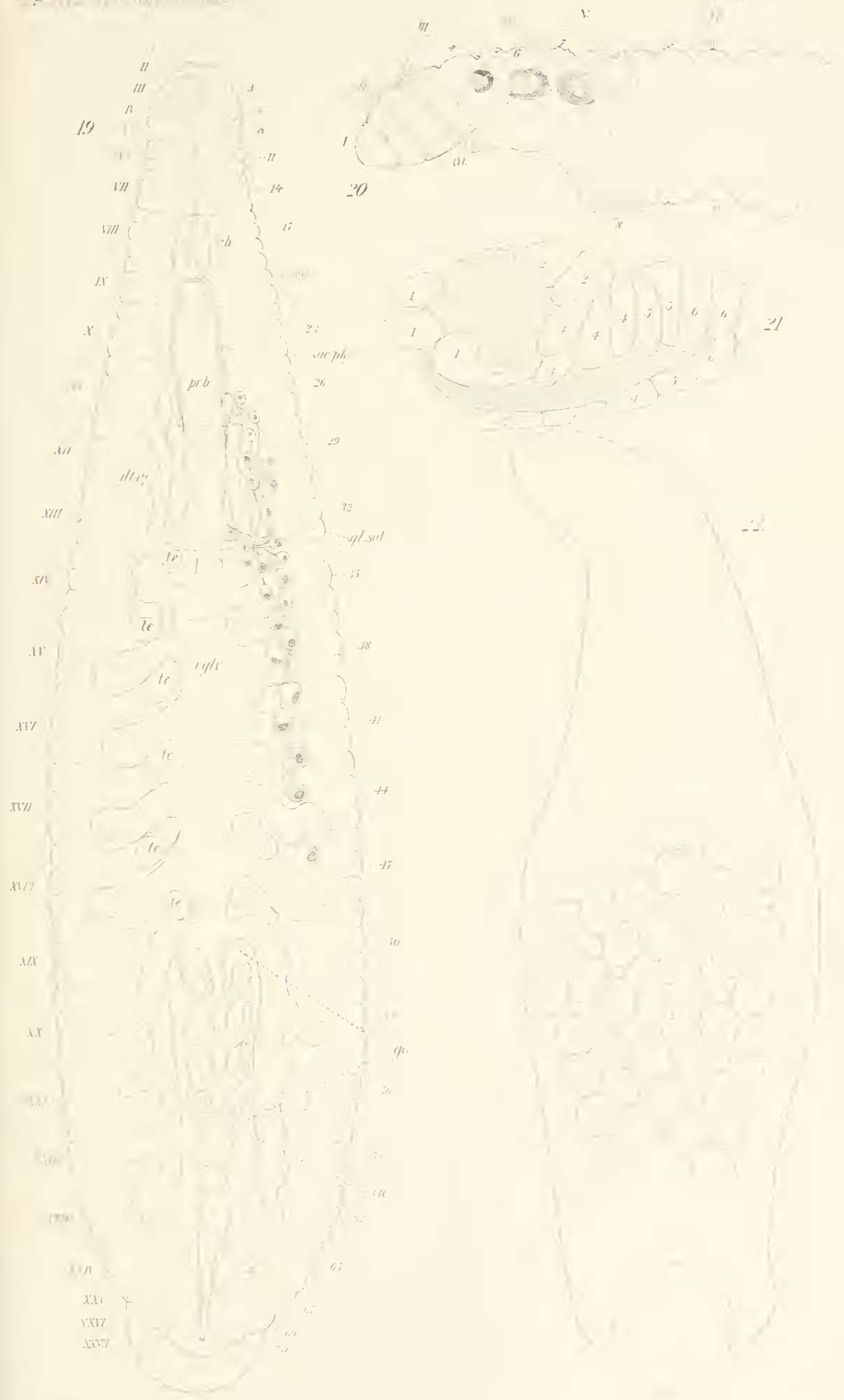

19
20
21
22
prb
dtg
te
gl.sal
sacph

PLATE 6.

G. elongata.

All figures of this plate were drawn from whole preparations. *Annuli in Figures 23 and 27 are numbered from the posterior margin of the oral sucker backward.*

Fig. 23. Head end viewed from right side.
Fig. 24. Posterior end of body viewed from right side.
Fig. 25. Brain, ventral view.
Fig. 26. Brain viewed from right side.
Fig. 27. Ventral view of entire animal partially contracted. In somites VII.–XXII. furrows between annuli are shown only at the margin of the body, except where they mark somite boundaries.


23
25
or
27
24

PLATE 7.

G. elegans.

Fig. 28. Dorsal view of a young individual. In somites VI.–XXV. furrows between annuli are shown only at the margin of the body, except where they mark somite boundaries. Reproductive organs and salivary glands drawn from other, older individuals; salivary gland cells a little too small. From an entire preparation.

Fig. 29. Parasagittal section of head end.

Fig. 30. Head end, dorsal view. From an entire preparation. × about 50.

Fig. 31. The same, ventral view.

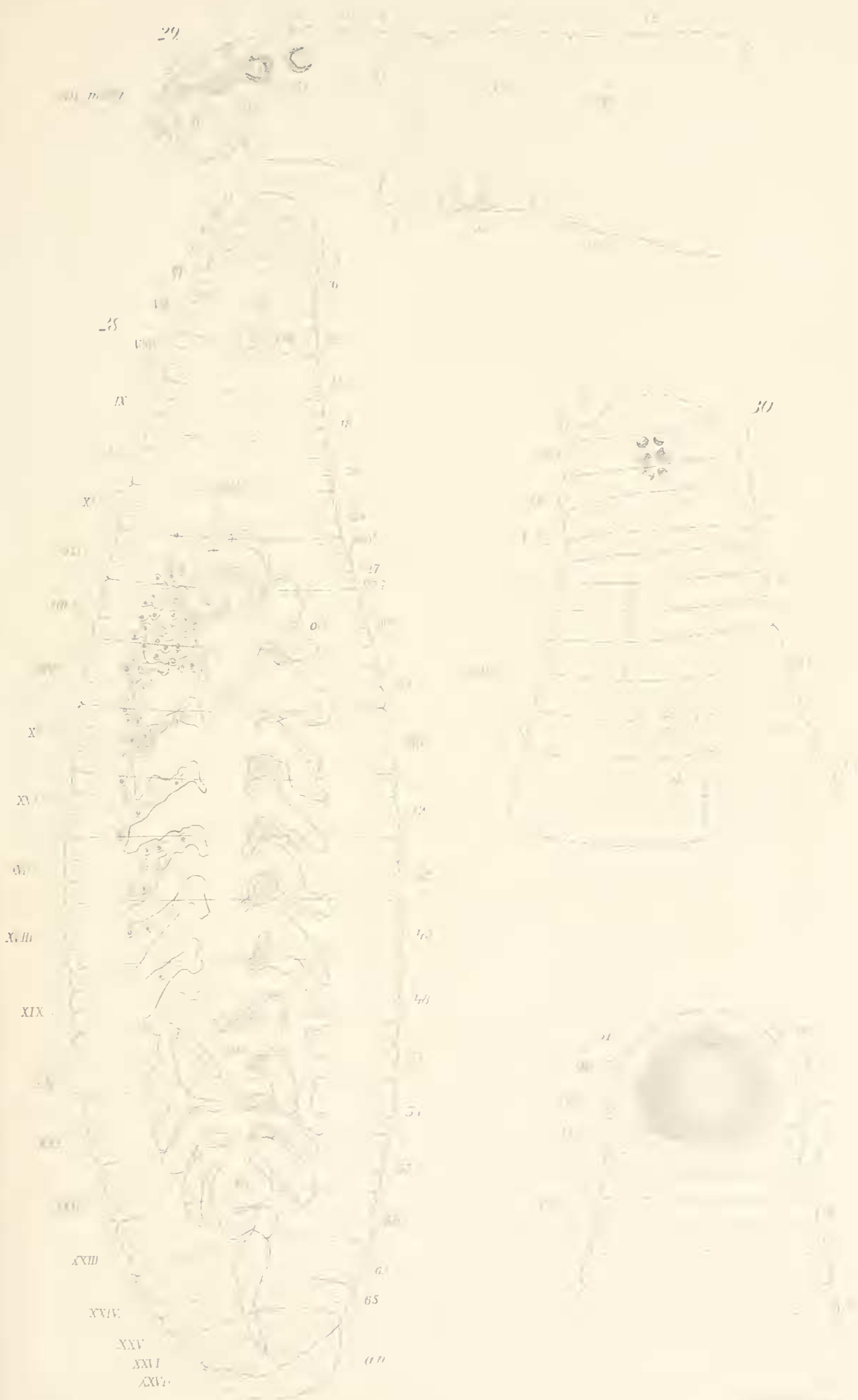

29
30
IX
XIX
XXIII
XXIV
XXV
XXVI
27
65

PLATE 8.

Fig. 32. *G. parasitica, var. plana.* Dorsal view of head end of an individual from Havana, Illinois, in which the division between rings 2 and 3 was not evident. Stippling shows position of yellow pigment in a median vitta and (on left side) in metameric marginal spots. From an alcoholic specimen. × 41.

Fig. 33. *G. parasitica, var. rugosa.* Dorsal view of head end of an individual from Cambridge, Mass., showing the usual annulation of somites I.–III. From an alcoholic specimen. Enlarged.

Fig. 34. *G. stagnalis.* Dorsal view of posterior end of body. Enlarged.

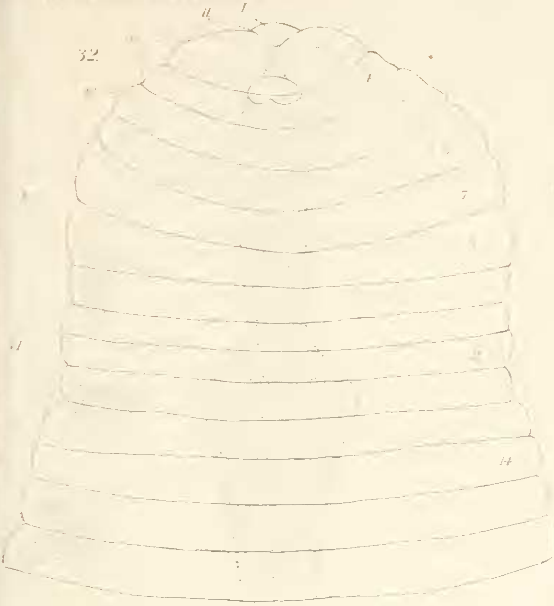
Fig. 35. *G. heteroclita.* Dorsal view of head end of a living animal, showing most common position of eyes. Enlarged.

Fig. 36. A dorsal view of the head end of the individual represented in Figure 38. The anterior ring of somite VI. is seen to contain traces of a transverse pigment line. Drawn from the living animal. Enlarged.

Fig. 37. *G. parasitica, var. plana.* Dorsal view of posterior end of body of the individual shown in Figure 32. Marginal light spots indicated by stippling. × 24.

Fig. 38. *G. heteroclita.* Dorsal view of a living animal, showing the general form of the body at rest, and the color pattern sometimes present on the dorsal surface. The rings are not indicated, but the numerals are placed opposite and serve to designate those rings in which the pigment is found (the anterior rings of their respective somites). Enlarged.

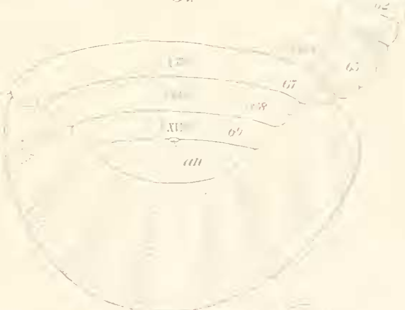
32.



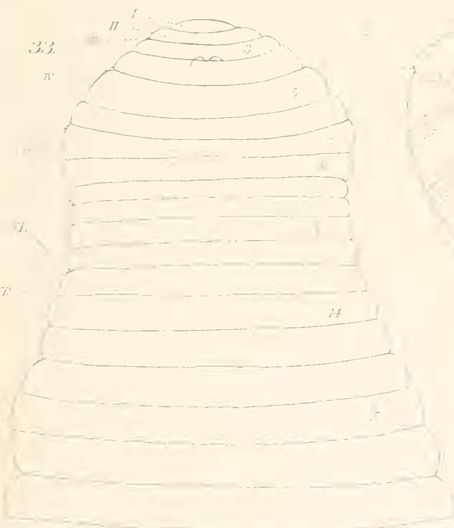
35.

36.

37.



33.



38.

34.